1960 NASA AUTHORIZATION

HEARINGS

BEFORE THE

COMMITTEE ON SCIENCE AND ASTRONAUTICS AND SUBCOMMITTEES NOS. 1, 2, 3, AND 4 U.S. HOUSE OF REPRESENTATIVES

EIGHTY-SIXTH CONGRESS

FIRST SESSION

ON

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1960 NASA AUTHORIZATION

HOUSE OF REPRESENTATIVES.
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
Washington, D.C., Monday, April 20, 1959.

The committee met, pursuant to notice, at 10:05 a.m., in room B–214, New House Office Building, Hon. Overton Brooks, chairman, presiding.

The CHAIRMAN. The committee will come to order.

This morning we have the annular National Aeronautics and Space Administration authorization bill for fiscal year 1960. This bill has been partially considered by the Senate committee and it is now before us. We have a list of witnesses, and we think this will take the better part of this week in order to cover this subject carefully, and it is entitled to our very best attention.

(The bill referred to is as follows:)

[H.R. 6512, 86th Cong., 1st sess.]

A BILL To authorize appropriations to the National Aeronautics and Space Administration for salaries and expenses, research and development, construction and equipment, and for other purposes

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That there are hereby authorized to be appropriated to the National Aeronautics and Space Administration for the fiscal year 1960 (a) such sums as may be required for "Salaries and expenses" and for "Research and development," and (b) the sum of $57,800,000 for "Construction and equipment," as follows:

(1) Langley Research Center, Hampton, Virginia: Alterations to thermal structures tunnnel; analytical computing equipment; conversion of gust tunnel to noise research laboratory; conversion of test cells to noise test facility; and heater and vacuum system for gas dynamics laboratory, $4,580,000.

(2) Ames Research Center, Moffett Field, California: Data reduction center and mass transfer cooling and aerodynamics facility, $6,555,000.

(3) Lewis Research Center, Cleveland, Ohio: Ion and plasma jet facility; zero-power reactor; inpile loop; and approximately twenty-five acres of land, $6,860,000.

(4) High-Speed Flight Station, Edwards, California: Building additions; analog computing equipment; and terminal guidance facility, $2,805,000.

(5) Beltsville Space Center, Beltsville, Maryland: Central flight control and range operations building; space sciences laboratory; instrument construction and installation laboratory; and utility installations, $14,000,000.

(6) Pacific Missile Range, Point Arguello, California: Launching facilities, including flight vehicle assembly and check-out facility with equipment for special experiments, $3,000,000.

(7) Various locations: Global range tracking and communication facilities and equipment; facilities for Rover program; and propulsion development facilities, $20,000,000.

(c) Appropriations for "Research and development" may be used for any items of a capital nature (other than acquisition of land) which may be required for the performance of research and development contracts.

(d) When so specified in an Appropriation Act, any amount appropriated for "Research and development" and for "Construction and equipment" may remain available without fiscal year limitation.

SEC. 2. Authorization is hereby granted whereby any of the amounts prescribed in subparagraphs (1), (2), (3), (4), (5), (6), or (7) of section 1(b) may, in the discretion of the Administrator of the National Aeronautics and Space Administration, be varied upward 5 per centum to meet unusual cost variations, but the total cost of all work authorized under such subparagraphs shall not exceed a total of $57,800,000.

SEC. 3. Any amount, not to exceed $5,000,000, of the funds appropriated for "Construction and equipment" pursuant to this Act, may be used to construct, expand, or modify laboratories and other installations, if found by the Administrator to be necessary because of changes in the national program of aeronautical and space activities or new scientific or engineering deveolpments and if the Administrator determines that deferral until the next authorization Act would be inconsistent with the interests of the Nation in aeronautical and space activities, and in connection therewith to acquire, construct, convert, rehabilitate, or install permanent or temporary public works, including land acquisition, site preparation, appurtenances, utilities, and equipment: *Provided*, That upon reaching a final decision to implement, the Administrator or his designee shall notify the Committee on Science and Astronautics of the House of Representatives and the Committee on Aeronautical and Space Sciences of the Senate of the cost of such construction, expansion, or modification including those real estate actions pertaining thereto: *Provided further*, That no such funds shall be used for such construction, expansion, or modification if authorization for such construction, expansion, or modification has been previously denied by the Congress; and additional appropriations are hereby authorized for purposes of this section in the amount of $5,000,000.

The CHAIRMAN. We are privileged this morning to have as our first witness, Dr. T. Keith Glennan, who, as you know, is in charge of the National Aeronautics and Space Administration as Administrator. We have had the pleasure of having Dr. Glennan before with us, and we are happy to have him this morning again.

The second witness will be Dr. Hugh L. Dryden. We know Dr. Dryden also very capably because of his appearances. Dr. Dryden, I am told, will have a film that will be classified. When we come to that point in the course of this testimony, we will have to clear the committee room for an executive session. Following that we will have Dr. Abe Silverstein, and he has a short presentation which also is classified, and also it will be necessary to remain in executive session.

Dr. Glennan, I think we have a copy of the statement which you have in mind this morning. If you would proceed with it, we would appreciate it.

STATEMENT OF DR. T. KEITH GLENNAN, ADMINISTRATOR, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Dr. GLENNAN. Thank you, Mr. Chairman. I am particularly happy to hear you are going to devote a substantial number of hours to listening to the presentations which have been prepared. This is a very fast-moving, new field. I think it is very important that the Members of the Congress understand the ramifications of the kind of program we are laying out. It is an important one in the future of the Nation and we can't spend too much time in trying to have you understand these matters.

I want to thank you for this opportunity to present NASA's $485,300,000 budget appropriation request for fiscal year 1960. This figure represents an increase of $101,226,468 over the amount available for fiscal year 1959, including supplemental appropriations now under consideration by the Congress.

We have available to assist you in your deliberations several responsible NASA officials who will present a program-by-program justification of our request for funds in the following three categories: $94,430,000 for salaries and expenses; $333,070,000 for research and development; $57,800,000 for construction and equipment.

But I would like the privilege of giving you a broad picture of the activities to be supported from the funds we seek.

As you know, this is the first full year budget for the NASA which the Congress and the administration are presenting to the American people.

It is my judgment and the judgment of the scientists and engineers who carry responsibilities for our program that this is a sound budget which will allow us to push our space program with maximum effectiveness.

The public has a right to know and, in many ways, a duty to attempt to understand how we justify the expenditure of millions of dollars probing the unknown.

Why are we exploring space? The answer is many sided:

The scientist seeks knowledge for its own sake, knowing that scientific progress has always benefited man in the long run.

The realist may be more concerned with the practical applications of space technology, the dollars and cents return on weather forecasting, on communications, and navigation satellites, for example.

Industrialists and economists are excited by the stimulus a new technology is bound to give our industrial complex; they envision whole new industries being born.

The military men see space in terms of defense applications.

Students of all ages and every country look at space as a previously unknown dimension of the universe being made capable of more understanding.

But there is still another and overriding reason for our program of space exploration. The National Aeronautics and Space Act of 1958 stipulates that "activities in space should be devoted to peaceful purposes for the benefit of all mankind," and that a civilian agency, NASA, should direct these activities.

We are engaged in a struggle for the minds and hearts of men everywhere. The issue is simply whether our system of free government and responsible civic freedom is superior to the system of totalitarian communism and forcible direction of the lives of its captive peoples.

I believe it is becoming increasingly obvious to the world that Russia's space activities are devoted, as are most of their activities as a nation, in large part to the furthering of communism's unswerving designs upon mankind. This is becoming evident in the secrecy which surrounds their failures, the propagandistic promotion of their successes, and their unwillingness to make full disclosure of their findings for the benefit of the scientific and world community.

By way of summary, we are planning to spend increasing amounts of money in space research because:

Our national security is vitally involved.

Undoubted economic benefits will accrue.

An increase in man's knowledge about the earth and the universe will come about.

And finally, we know that the Soviet Union is in this business and that their successes thus far have been impressive. I cannot believe that they will withdraw from a race in which they hold even a slight lead. Have we any choice, as leader of the free world, but to press forward with diligence on a well-planned program for the exploration of this new environment?

The late Robert H. Goddard, father of American rocketry, once wrote:

> My earliest recollection of a scientific experiment dates back to when I was 4 or 5 years old, in Roxbury, Mass. I had heard of electric sparks being produced by a person who scuffed along a carpet, and I had seen electricity produced by a Leclanche battery, so one day I obtained the zinc from one of these batteries and scuffed along the gravel walk. Next, I mounted a low fence and jumped. Then I repeated the experiment, scuffing over a longer distance, and endeavored to convince myself I had jumped higher.
>
> My mother caught sight of this investigation and called out to me to be careful because it might work and I might go sailing away without being able to come back. After this warning I hid the zinc rod and never repeated the experiment.

Fortunately, this was but a single incident in his life, and did not serve to eradicate the spirit of scientific inquiry that led Goddard to his great concepts of rocketry and space travel.

We in the United States are strong on technology but all too weak in basic research. Part of the money we request is to be devoted directly or indirectly to basic research, to "refilling the reservoir of knowledge"—to employ a trite phrase. There is no reason to doubt that from space research will come concepts every bit as exciting and as far reaching economically as atomic energy. But we have got to be willing to respect basic research and support it.

This is not to say that practical applications are not already on the horizon. More than 6 months have passed since NASA became officially operative, and it is now possible to bring the road ahead into sharper focus. I would like to talk briefly about the future—about our objectives.

In this business it is very tempting to prognosticate, to engage in what we call blue sky talk. Without indulging in too much of that sort of thing, it is clear that long-range objectives make this business exciting both by reason of the new knowledge that is sure to be found about our universe and about man's place in it, and by the probable application of some of that knowledge to the solution of hitherto seemingly insoluble problems.

For more than a decade we have been probing the upper atmosphere with sounding rockets, to an altitude of about 150 miles, to learn what we could about its composition. Our new space vehicles now enable us to pursue these studies more effectively and in more detail. What we learn about our atmosphere will help prepare us for the more difficult study of atmospheric conditions on the planets.

During the next few years we will step up scientific investigations of the upper atmosphere and space with sounding rockets, Earth satellites, and space probes. These investigations will include measurements of particles and micrometeorites; the Great Radiation Belt; aurora and ionospheric characteristics; electric, magnetic, and gravitational fields; astronomical data, relativity checks, and biophysical experiments.

Finally, investigation of the solar atmosphere and its effects on our atmosphere and those of the other bodies in the solar system will be attempted with deep space probes. We will be making repeated measurements in order to obtain a continuous picture of our space environment.

Our Project Mercury is the first step toward space flights by man to the moon and the planets. This is one of our most challenging objectives—manned space flight. Before the first American steps onto the moon, however, or even rides out into space for any very great distance, we will have to deal with the following problems:

The deadly radiation discovered by the U.S Explorer satellites and Pioneer space probes.

Man's ability to withstand long periods of loneliness and strain while subjected to the strange environment of weightlessness.

Atmospheric reentry and safe landing.

Man's behavior and reactions in space flight will be carefully studied. Such studies should greatly increase our knowledge of man himself.

In the next decade we hope to be sampling physical quantities in the vicinity of the planets. Soft landings of instrumented payloads will be attempted on the Moon, Mars, and Venus to determine surface and atmospheric properties of these bodies and whether some form of life exists there.

We are already studying space rendezvous techniques against the time when space laboratories will become a reality.

As you know, the foreseeable practical applications fall into the fields of meteorology, communications, geodetics, and navigation.

Although it would be wrong to believe that weather satellites will solve all the mysteries of the winds and tides, they will greatly expand the scope and improve the accuracy of weather forecasting. It seems probable that a weather satellite system providing 24-hour-a-day worldwide coverage will become a reality in the years ahead. These satellites would employ radiation detection equipment, including television, infrared detectors, and radar to measure temperature, wind direction, cloud cover, storm location, precipitation, heat balance, and water vapor.

Our Vanguard II satellite recently gave us the first real glimpse into this area of activity. Our 1960 budget request contains funds for further development of weather satellite systems.

I think we can all appreciate what this will mean in terms of protection of life and property from hurricanes, typhoons, and other storms.

The potentialities of communications are equally interesting to contemplate. Long-range communication by telephone, telegraph, and television is now carried by landlines, cables, and long and short wave radio and microwave stations. The total bandwidth of land lines, cables and low frequency radio is limited. Atmospheric interference and ionospheric irregularity render short wave radio bands unreliable. Ultrashortwave and microwave radio is usually limited to line-of-sight range; long-distance communication at these frequencies is commonly achieved by means of repeater stations.

Day by day it is becoming increasingly evident that our communications capabilities—both civilian and military—will soon fail to meet

increasing demands by a large margin. I am told that the transatlantic cable, with 36 voice channels, will be swamped by 1962. It is forecast that there will be a sevenfold increase in message units between 1960 and 1970. A single television channel is the equivalent of 1,000 voice channels. Here is a problem a real significance.

Satellites should make possible worldwide communications of ultrashortwave or microwave radio because the line-of-sight range at satellite altitudes is very great. The bandwidth or channel capabilities at these wavelengths are sufficient for television and most other foreseeable communications needs. This, then, is a prime objective—to develop the basic information and technology necessary to permit the building of a satellite-based communications system at an early date.

As Goodard once said:

> It is difficult to say what is impossible, for the dream of yesterday is the hope of today and the reality of tomorrow.

Mr. Chairman, our agency is proud to have the responsibility for the exploration and exploitation of space for the benefit of mankind. While we must recognize and concede the importance of possible use of space to accomplish military missions and objectives, the longrun objective of this Nation—indeed its primary objective—is peace. We in NASA have the responsibility for making a real contribution toward that objective as we raise men's eyes toward these new horizons. To discharge that responsibility, we need the funds for which we have asked. I urge upon you prompt and favorable action on this budget request.

The CHAIRMAN. Thank you very much, Dr. Glennan, for a very fine, imaginative, and yet realistic statement. I might say this—and I say this for the committee—later on we will take up the bill, item by item, and we will have witnesses to support each item.

At this time I would suggest to the members of the committee that we ask Dr. Glennan any general questions and policy questions, which may be in the minds of the members of the committee, and at a later date we will get into the technical points of the bill itself.

I want to say this, I am glad we have our colleague, Mr. Miller, back this morning, because I have been hearing about his difficulties on his flight west to see one of the Discoverer launchings. We are lucky to have you back, Mr. Miller. Do you have any comments to make or any questions to ask?

Mr. MILLER. Other than this, I am a firm believer that we should have more and bigger and better emergency landing fields throughout the country. When you land in a cornfield at 7 o'clock at night with one motor burned out windmilling, and a second motor on the same side having to be stopped, you come to the conclusion that there aren't enough emergency landing fields, and they are not well paved.

I do want to compliment, though, the crew of American flight 707 that we were on for the way in which they handled the matter, and thank God that they got the plane stopped where they did, because about 150 feet out in front of us was a swale that went down about 20 feet. If we had overrun that I guess we would have been on our nose.

I am sure that Mr. Godel—he is not here of course—and Mr. Minnich of the White House staff and some of the others echo what I have to say for the other 57 members on the plane.

Dr. GLENNAN. I am informed there were two other members of our staff on that plane.

Mr. MILLER. Who were they?

Dr. DRYDEN. Mr. Tischler and Mr. Bessio.

The CHAIRMAN. We want to welcome them here, too. [Laughter.] Mr. Miller, do you have any questions now this morning?

Mr. MILLER. No, I don't. I want to compliment Dr. Glennan on the very fine statement, as usual. Doctor, is there enough funds for next year?

Dr. GLENNAN. That is a question that is never easy to answer. I would not be unrealistic and say that we couldn't use another dollar, but it is my considered opinion that with the present state of the art, the present state of development of our activities and organization, that the moneys we are asking for will enable us to get ahead very well with the program that we have laid on.

There is a pace, I think, beyond which one doesn't go with good judgment in matters of this kind. When you are dealing with new elements of science, working in a new environment, and developing new technologies to support that science, it just takes a certain amount of time, and it certainly takes the time to acquire really good people.

So I must, I think, simply answer your question by saying that, as of the present time, I think we will get ahead very well with what we have asked for.

Mr. MILLER. I am very happy to hear you say or to imply that you can't put together a team of good people overnight. I think that is something the American people do not realize, and that many Members of Congress are not conscious of. In doing a task such as has been given to you requires the assembling of competent people. To me that is one of your biggest problems at the present time.

Dr. GLENNAN. It certainly is.

Mr. MILLER. I have no further questions.

The CHAIRMAN. Any questions of Dr. Glennan?

Mr. King?

Mr. KING. Dr. Glennan, there came over my desk a few days ago an advance copy of an article—I assume the other Congressmen received the same—written by a Mr. Lloyd Mallan called "The Big Red Lie." This article will appear popularly in a magazine soon.

The burden of the article was that about 50 percent of what Russia is allegedly doing is just the result of some very high-powered, but deceptive propaganda on the part of Russia.

He apparently had an opportunity of talking to most of the really topmen in the Soviet Union in charge of their missile program, and he was convinced when he got through that they were trailing us by a wide margin.

He admitted that they were ahead of us in developing sort of a primitive thrust. They did get Sputnik into the air—he doesn't question that—and they were actually able to build up more poundage of thrust than we have. But that that is absolutely the only area in which they have done anything that we have not done. And, on the other hand, he said, in all of these other areas of instrumentation and tracking—well, in fact, everything except the pure matter of thrust—they were trailing us by 10 to 15 years.

The article came so shockingly to me as being contrary to what we had heard in all of our testimony, I would like to ask you first if you

have any comment; and, secondly, that if what Mr. Mallan says proved to be true, or even partially true, whether that would affect your approach on this matter of the budget?

I would like you to discuss that for a minute.

Dr. GLENNAN. Mr. King, having spent a few days in Russia looking at the activities in some of the institutions of higher education there last summer, I think I would have to say that one could draw whatever conclusions he wanted to draw from what he saw there, and from what he heard there.

I am inclined to believe that the area in which the Russians do exceed us in capabilities is in this particular area of thrust, when we limit our discussions to the space field.

I did see a large 10 billion electron volt cosmotron. I did see a 680 million electron volt synchrocyclotron. They were operative. Good papers have come from them.

We find our friends in the steel industry coming back somewhat astounded by the quality of the steels they have been making over there and the efficiency of their operations.

I think, taking the reactions that I have been able to gain from qualified scientists in these varieties of fields, and from some of the industrialists who have gone over there, as well as my own firsthand observations, that it would do us no good at all to sell them short.

Let me go back and say that I saw this same article—although I have not had a chance to study it. It is on my bedside table at home. I note this propagandistic piece of the Univac with the name removed, and that sort of thing. This is the sort of thing we really can't understand, I believe—this purported to be a Soviet computing machine, a development of the Soviet Union, and yet it was obvious that it was just a copy of the photograph of the Univac installation.

These things, I am sure I could give you, and would be glad to when we don't have to take the time of the whole committee—incidents that would raise questions in your mind as to the validity of some of their statements—many of them, perhaps.

But by and large I do believe they have the technical know-how, they have the industrial capacity to build the things that they need to build. I saw some of the plants. I saw the results of those plants, the work of the plants. I think I would like just to repeat I think we would do ourselves a disservice if we sold them short and said, "Well, we can go back to our knitting and play baseball again."

Mr. KING. I am glad to hear you say that. The article disturbed me a little bit, because I felt, as you apparently feel, that a disservice could be done to the American public if they are of a mind that they are trying to find some excuse not to do this, and then this article would come out and that would give them the excuse. That would lull them into a false security. To me that would be very dangerous.

Dr. GLENNAN. Mr. King, I think what I take from all of these discussions is that while we don't want to sell these people short, neither do we want to simply imitate what they do and try to beat them at this, that, and any other thing they have set themselves up to do. We as a nation didn't grow the way we are by doing that

kind of thing, and it is time we started to get our house in order and decide what we want to do, and do it.

Mr. KING. I agree.

Dr. GLENNAN. That is what I am trying to say with respect to this program.

Mr. KARTH. Doctor, I too was interested in this article. The fact is I had one of my staff send it down. This is the one Mr. King was referring to, I am sure.

Mr. KING. Yes.

Mr. KARTH. I was wondering whether or not we were being misled on this committee by government officials on our own part to stir us into an emotional upset, so to speak. If you get a chance to read this—and I would suggest you do it as quickly as you can, Doctor——

Dr. GLENNAN. I have scanned it. I have not read it in full.

Mr. KARTH. He says the Soviet Union's first manmade planet Lunik does not exist, and never did. This is the one that is supposed to go around the Sun.

No. 2, the Russians do not have any ICBM's, the long-distance missile with which Khrushchev has threatened this country. Just let me read two short passages from the text here. He says:

> I had come out of Russia with the dead certainty that the United States was immeasurably far ahead in space technology, that for one thing Russia had no effective intercontinental ballistic missile, and that for another the United States would beat Russia to the Moon without half trying.

And he goes on to say:

> It was a hard concept to grasp, both intellectually and emotionally, but this was it. The Russians did not fire a rocket past the Moon on January 2, 1959. If they fired anything, it failed to reach the distances achieved by the U.S. Pioneers. The Lunik, in short, was a coolly insolent magnificent international hoax.

The reason I read this, the whole theme of this article is that we have been so badly misled on the progress that Russia has made in this whole field of space. He does admit that they have ideas, that they have theories, that they do have some things on the drafting board, so to speak. But this is about as far as they go in this whole field of space.

After making some 14,000 miles in Russia itself, that we have been so badly misled here that this Russian propaganda, the "Big Red Lie" as he calls it, has overpowered us to such a degree that we have become almost hysterical, when really there is absolutely no reason for us to feel that they are within even—as Congressman King has said—10 or 15 years in technology to us.

Maybe some of the staff may want to take a look at this. So this was very interesting to me. This man apparently has quoted in several places throughout the article here that he is recognized as quite an expert in this field, and I was just wondering whether or not any one of your staff, Doctor, may want to comment along with you on this.

Dr. DRYDEN. There is no question that the Lunik was fired, and it did approximately what the Russians said.

Mr. KARTH. May I interrupt you there, sir? He says he can get no information from any one of the tracking stations or any one of the agencies in this Government to verify that they had any knowledge—

that is, concrete knowledge—and could say that this shot was really made, and that they heard it, they received signals from it.

Dr. DRYDEN. If he will write to us, we will give him the technical information. There is no question that it did approximately as the Russians said.

Dr. GLENNAN. I think I would add one thing there, Mr. Karth. Facetiously you might say this man might just as well have stayed home. Fourteen thousand miles is a long way to go to get misinformation, or to draw erroneous conclusions.

I spent a little time in the atomic energy business back in 1950 to 1952. We became aware, as you know, in 1949 that the Russians had actually exploded a nuclear device. I don't know whether it was a bomb or what it was—a nuclear device. You don't build nuclear bombs and you don't test nuclear bombs without a tremendous amount of scientific know-how, technological know-how, and industrial background. It just isn't done.

It has taken a lot out of this country to get that done. They have been firing these at a rate made known to the public, which would indicate they either have plenty of them to fire, or that they are running again one of the biggest propaganda hoaxes of all time. I choose to believe the first.

I think what we are attempting to say to this committee is our honest judgment. We aren't trying to kid you about anything. When we start kidding you about it, then I want to go back home.

Mr. KARTH. I was certainly compelled, Doctor, not to agree or take too seriously what this article said. I wanted to hear you say it, and I am going to ask some other people who will appear before this committee what their feelings are on the matter. I am very glad that you did make the statement.

The CHAIRMAN. Will the gentleman yield to Mr. Miller?

Mr. KARTH. Yes, sir.

Mr. MILLER. I would like to say for the benefit of my colleagues—and I am a little older than you are—that many years ago we heard a lot of propaganda in this country that the Japanese couldn't fly because of certain physical imperfections, and that we didn't have to fear Japan in the air. I think the world learned the hard way.

We were told later on that the Russians didn't have the capability of putting good airplanes into the air, but a plane called the MIG gave us a great deal of trouble when the chips were down. So this looks to me like a little counterstuff. It is the same kind of headline-seeking data, the kind of thing that certain Americans would like to be told.

I for one discount the article entirely. I would like the record to show that.

The CHAIRMAN. Mr. King?

Mr. KING. I would like to make this statement, in the light of what Dr. Dryden has said about the Lunik. This article appears, then, to be nothing more than sensational and yellow journalism which upsets me no end. I feel that the American public are going to grab hold of that article when it appears popularly on the news stands, which it will within 3 weeks. It seems to me it would behoove all of us to try to exercise a concerted effort to set the record straight.

I think an article like that would do incalculable harm if it isn't given some sort of official answer. I just suggest that it be given some thought to, that is all I have.

The CHAIRMAN. Dr. Hechler.

Mr. HECHLER. If the gentleman will yield, it may sell more if we call attention to it. I would like to ask Dr. Glennan on another subject. I notice on the first page of your statement that you make some comparisons with the fiscal year 1959, and you say:

> This figure represents an increase of $101 million over the amount available for fiscal year 1959.

Dr. GLENNAN. That's right, sir.

Mr. HECHLER. I suggest perhaps you have been mathematically unfair to the Agency, which I don't believe has been in operation for the full fiscal year, has it?

Dr. GLENNAN. I think that implication could be drawn, and properly so.

Mr. HECHLER. I do not want to get, Mr. Chairman, into a detailed examination of these figures, but I wonder if you, Dr. Glennan, or Dr. Dryden, could submit for the record a comparison of the specific figures which would project them in such a way that we can have a clear comparison of expenditures for fiscal 1959 with the request for fiscal 1960?

Dr. GLENNAN. We will go into that.

Mr. HECHLER. Thank you.

The CHAIRMAN. Doctor, may I ask you a question or two now? Of course I know the Discoverer shot was an Air Force shot, but do we have any information on the Discoverer shot available here that you could give this committee, especially regarding the—should I call it—mistake in not being able to bring the Discoverer down in the proper place?

Dr. GLENNAN. Mr. Chairman, I would suggest that you would get more accurate information from Mr. Johnson. My understanding is that a timing device did not function properly—something I am afraid we have to expect from time to time in new devices of this kind.

The CHAIRMAN. I heard something somewhere that one of our men in one of the outlying distant bases had sought to contact the Discoverer in orbit and the machine had functioned, but the mistake was in the personnel in making application to the satellite at the wrong time.

Dr. GLENNAN. I am not prepared——

The CHAIRMAN. Do you have any information regarding the efforts to locate the warhead?

Dr. GLENNAN. I do not have detailed information on that. I have some information which I would be glad to talk with the committee about in executive session.

The CHAIRMAN. You will give us something in executive session. Let me ask you this. A good deal of time has passed since the Russians sent up their last satellite, or rather the last deep probe into the lunar regions and then in orbit around the sun. Do we have any information that you could give us in open session as to what the Russians are doing in the interim, and what their next program is?

Dr. GLENNAN. No, sir, I don't think I could give you any information, Mr. Chairman, on that.

The CHAIRMAN. You couldn't say whether or not their next program is a man-in-space program?

Dr. GLENNAN. We have had the usual information coming from scientific journals, and that type of thing, indicating their very great interest in placing a man in space. The types of experiments that they have made using dogs and that sort of thing certainly would indicate that this is the direction in which they are pointing.

The CHAIRMAN. So you think the direction still remains the same—that is, toward a man-in-space vehicle? Have you any estimate as to when they may achieve, or may attempt the achievement of that objective?

Dr. GLENNAN. I really don't, Mr. Chairman. I think both Dr. Dryden and I have the feeling that they have perhaps an earlier capability in making the attempt if they want to do it. This arises out of the fact that they have been in this business a little bit longer with propulsion vehicles of a greater capacity and capability than ours.

The CHAIRMAN. In making that observation, you are really applying our own experiences and projecting them to their experiences?

Dr. GLENNAN. That is right, sir.

The CHAIRMAN. We don't have any information available anywhere to indicate they have given up an interest in space, do we?

Dr. GLENNAN. No, I don't think so. Certainly I wonder at times, as I know the members of this committee must, why they don't fire more frequently than they do. One can only imagine, I think, that they have set a particular course for themselves and that they are laying—as they normally would do—all their efforts on that particular course.

If this happens to be man in space, I think that there is a reasonable chance that they are going to be able to launch that man within a reasonable period in the future.

The CHAIRMAN. Do you think that they are experimenting in discharging missiles or rockets in space, and we don't know about it?

Dr. GLENNAN. I can't believe but what they are continuing to experiment with missiles and rockets, Mr. Chairman. But I don't have direct information on that.

The CHAIRMAN. We have no record, do we, of any missiles, outside of satellites, of the Russians having fired anything beyond the territorial limits of Russian Siberia, do we?

Dr. GLENNAN. I am not aware of any.

The CHAIRMAN. The overall amount you set forth in this bill, I think you stated you thought would be adequate for the next 12 months?

Dr. GLENNAN. Right, sir.

The CHAIRMAN. You gave us a very extensive and a very fine briefing on the work of NASA earlier in this session. Are there any changes in the program of NASA that you would like to present to this committee?

Dr. GLENNAN. Would like to present to the committee? I think this will be done by the gentlemen who are going to support these activities, and there will be a sufficient extrapolation so that you can see where we are heading, Mr. Chairman.

The CHAIRMAN. So there are no major changes. Otherwise you would have wanted to present them yourself.

Mr. Sisk?

Mr. SISK. Dr. Glennan, I would just like to inquire along the lines of the chairman's last question there. This goes back to your recommendations last year, and further statements as to reviews of the problem regarding your taking over a substantial part of the personnel of the Army Ballistic Missile Agency.

What is your thinking on that at the present time?

Dr. GLENNAN. It hasn't changed, Mr. Sisk. We are using the Army Ballistic Missile Agency for quite a number of activities. We have recently given them responsibility for two or three particular payloads. This relationship seems to be working out very well indeed. There has been no real change in the situation since I last saw you.

Mr. SISK. There has been no recent review of any decision on this matter?

Dr. GLENNAN. No, sir.

Mr. SISK. Let me ask you this: You speak about the contracts you have. Can you give the committee the total of the contracts you have with ABMA at the present time?

Dr. GLENNAN. I will be glad to supply it to you. I think it is in excess of $20 million, and probably close to $24 million, as I recall it.

(The information is as follows:)

As of this date, $22,976,000 has been allocated for seven projects which are being conducted by Army Ballistics Missle Agency for the National Aeronautics and Space Administration.

Mr. SISK. That frankly was my understanding. It is somewhere around $20 million to $25 million. Frankly that was the thing that caused a little bit of concern. Do you feel that you are utilizing the services of ABMA to the fullest extent?

Dr. GLENNAN. I think we are utilizing the services of ABMA to the fullest practicable extent at the present time, Mr. Sisk.

Mr. SISK. Are there reasons why you are contracting out into other sources substantially greater contracting size than you are granting to ABMA? Is there some reason for that?

Dr. GLENNAN. Yes, the fact that we are using Thor boosters and Atlas boosters. We would normally then go to the Ballistic Missile Agency of the Department of the Air Force for their assistance in matters of that kind. As our program moves along, we will be moving away from the Jupiter-Redstone missile group as being inadequate in capability to handle the satellites, probes and payloads that we send aloft.

Mr. SISK. Let me ask you this: With the proposed budget now which you have outlined here in total, can you give the committee any information as to what percentage of that may be placed with ABMA?

Dr. GLENNAN. About the same amount.

Mr. SISK. About $20 or $25 million?

Dr. GLENNAN. That's right, sir.

Mr. SISK. That then leads me to some concern. I am a little bit curious, then, as to why your original interest, Dr. Glennan, and the desire apparently of NASA to absorb the personnel, the team of ABMA, because apparently there is no intention to use them to any extent then in your program.

Dr. GLENNAN. Mr. Sisk, I think you may be missing one very important factor here.

Mr. SISK. Possibly so. I wish you would enlighten me. That is why I am asking the questions.

Dr. GLENNAN. They are very heavily engaged at the present time on a booster called Saturn, and this is taking up a very substantial amount of their capacity, so they are engaged in space activity almost wholly, I would think. I think this is the reason for the statement about their activities at ABMA.

Had they come over to our jurisdiction, we would be supporting Saturn instead of ARPA.

Mr. SISK. Do you feel that there is any disadvantage to the Saturn program by it being handled as it is being handled?

Dr. GLENNAN. No, sir. We are represented on the management committee that is dealing with Saturn. We may well have the first flight with Saturn. We are very much interested in it. We think it is going along very well indeed. We have recommended that additional money be placed on it, which was done.

Mr. SISK. In other words, as I understand you, then, you are completely satisfied with the way that contract and that program is being operated by ABMA?

Dr. GLENNAN. As of the present time, we are, sir.

Mr. SISK. You do not feel there would have been any particular gain had it been transferred to NASA?

Dr. GLENNAN. I wouldn't want to go on record as answering that one way or the other. This would seem to me to be casting aspersions at our good friends in ARPA and I don't propose to do that. I think they are doing a good job, and we are working with them, and we are satisfied that we are both getting on with the job that needs to be done.

Mr. SISK. I appreciate that, Dr. Glennan. I did not in any means intend to place you in a position of taking sides against ARPA. The only concern—and I know others have shared this because they have asked me to what extent the capacities, the ability, of ABMA to perform was being used.

There has been some question, and frankly there has been a question in my mind, whether or not they are being used to their fullest capabilities down there, because that team in my opinion is one of the greatest teams in the Nation.

Dr. GLENNAN. We quite agree with that.

Mr. SISK. In the progress they have made in this field. I am just concerned about the relationship between NASA and ABMA because we have a military responsibility, and I think ABMA should—I say this for the record, I have taken a position contrary to yours originally about this transfer, because I felt that because of this military responsibility, these people should stay where they were as a team and have not been too favorable, let's say, to any mass transfer here.

But at the same time it was my understanding that your relations with ABMA were very good.

Dr. GLENNAN. They are.

Mr. SISK. The last time you testified before.

Dr. GLENNAN. They are.

Mr. SISK. Therefore that was the reason for my question with reference to the amount of work that was being placed with ABMA. They have at no time failed to cooperate with you, then, is that right?

Dr. GLENNAN. Not in any instance.

Mr. SISK. You feel they are working to the fullest capacity they possibly could at the moment in this Saturn program and with reference to its tie-in with the overall space program?

Dr. GLENNAN. Yes, sir.

Mr. SISK. I think that is all, Mr. Chairman.

The CHAIRMAN. Mr. Wolf.

Mr. WOLF. Dr. Glennan, you are talking here about—in this No. 2 item, H.R. 2699—research and development $333 million, a third of a billion dollars.

Dr. GLENNAN. Yes, sir.

Mr. WOLF. That is a pretty general classification for $333 million. I wondered if somewhere there is a breakdown—

Dr. GLENNAN. You will get a full disclosure of the whole thing. This is just a general statement. We have this staff of experts back of me to give you a detailed breakdown on everything you want to know.

The CHAIRMAN. May I say this to all of the members of the committee, some of whom came in a little late. We do have backup witnesses for all of these items. We expect to explore each one very carefully.

Mr. WOLF. I think my questions would be better fitted, then, of the backup witnesses.

The CHAIRMAN. Mr. Fulton.

Mr. FULTON. We are glad to have you here, sir. We are interested on this committee to see that there is adequate progress made in the space and science fields.

On the salaries and expenses, are you contemplating expanding present personnel, or is that pretty much the same personnel that you have?

Dr. GLENNAN. Mr. Fulton, we do have a complete story for this in our backup presentation.

Mr. FULTON. That is detail. Your general policy is what I am interested in.

Dr. GLENNAN. Actually we are proposing to expand our staff by approximately 1,027 positions.

Mr. FULTON. You recommend that as necessary?

Dr. GLENNAN. Yes, sir.

Mr. FULTON. Would that particular expansion, as well as these other figures and programs, be within the President's budget as proposed?

Dr. GLENNAN. They will be.

Mr. FULTON. That applies to each of the programs, and no one of the programs is beyond the budget with another program less that you are recommending?

Dr. GLENNAN. If I understand your question correctly, the answer is "Yes."

Mr. FULTON. That means that each of the major programs is in line with the President's budget as well as the overall total, is that correct?

Mr. GLENNAN. That's right, sir.

Mr. FULTON. Then, as you remember last year, I have been one of those who wants to move with speed and move with dispatch for our own security and defense as well as that of the free world. Could you put in the record for us a calendar of shots and programs that are proposed under this program so that we can have a calendar set up

with a short explanation of the particular program, and the effect it has on the other programs, and why you have put this ahead in calendaring rather than some other program?

Dr. GLENNAN. Yes, sir.

Mr. FULTON. For example, on inserting Venus shots—you intend to insert Venus shots, do you not, between moon shots?

Dr. GLENNAN. We have a schedule of shots, Mr. Fulton, for the next 33 months which we will be glad to give you. These shots, each of them, I think, are reasonably identified. They are not pinpointed as to the exact date, because this is a very difficult thing to do. It would be impossible, as a matter of fact, to try to give you exact dates on these things. But within quarters or 6-month periods we will be glad to do that.

The CHAIRMAN. I am wondering here if in Mr. Fulton's testimony you could read that schedule.

Mr. FULTON. I would rather do that later.

Dr. GLENNAN. We can have that in an executive session.

The CHAIRMAN. I will ask you later on.

Mr. FULTON. We all know there is a certain restricted amount of hardware and equipment that can be used, as well as installations. So, of course, the judgment as to which program particularly and which show is embarked upon at a particular time involves the balancing out and the delaying of other programs. So when you make the calendar, I would like to see what the problems are as to each program and why certain ones were put ahead or others behind.

I have been at Cape Canaveral, as well as other members, a number of times, and I think we are educated above the eighth grade level in this particular thing after several years—that you can't say the time and the hour and the date. But we do want to see what your policy is relative to the expediting of these programs, which I am sure I feel are necessary for the safety and security of this country.

For example, I am very interested in the weather and navigation satellites. The people who live along flood areas—of course, floods and tornadoes as well as storms at sea, with people's lives being lost and tremendous damage—how soon would you be able to have a weather satellite program started or in operation?

Dr. GLENNAN. We have a meteorological program started. The first of the units was fired from a Vanguard not long ago. The question as to when one may have an operational system is quite another question because there is a very great deal of information to be acquired. There is much new technology to be developed. One of the very real problems, very great problems in this particular area, is how you really get back the information, digest it, pull out that which is useful, and rebroadcast it to the parts of the world that may need it.

This is not a program that is going to be done overnight, Mr. Fulton.

Mr. FULTON. But we already have a form of communications satellite with a capability already tested by two of the companies to discern large cloud masses or even large explosions. I would imagine you would be putting full steam ahead because if we had a weather satellite program, or meteorology or navigation program satellite in orbit, I believe that we might not even have to have the agreement with the Russians for the restriction on atomic explosions because we are insisting on an inspection system.

It would seem to me we would be able to circumvent and go around the need for an inspection system and the Russians and ourselves could quickly agree because we would be able to pick up any large-sized atomic or nuclear explosion that would cause danger. Isn't that correct?

Dr. GLENNAN. I would think this might possibly be done.

Mr. FULTON. Are you giving this the highest strategic priority—this type of a program?

Dr. GLENNAN. I think, Mr. Fulton, it is reasonable to state to you that we are giving the highest priority in our agency to the man-in-space program. The application of satellites for communications and meteorology are both receiving high priority. It is a little difficult actually to spike up each one of these to the height one would like to do with the knowledge that presently is available to us.

When you speak of a communications satellite that has been demonstrated, I would have to respectfully disagree with you. It has been made operable for a short period of time. The amount of information that will have to be gathered on communications satellites or meteorological satellites is very, very great indeed, and I would not want to have you or anyone else underestimate this.

Mr. FULTON. If you recall my language, the capability had been demonstrated: meaning that there is no new breakthrough necessary, and that the practical operations and the hardware could then be done if we proceed with an adequate program. I think we would agree that these aren't too far apart on what has been done.

I refer to the fact that the General Electric Co. of Philadelphia, Pa., has already advised that they could have a telegraphy communications satellite in orbit within a period of a year and have given an estimate of the cost of it. That kind of a communications satellite would have the capability of jamming radio, short and long wave, radar, and would have less of a capability, of course, on television.

When there is such a capability of having our own communications established when it is obvious that there is going to be a shortage of communications facilities in the near future, and secondly, when we would be able to jam any enemy communications of that nature, and thirdly, where it would put our Strategic Air Force into effective operation against any enemy communications of that type, why don't we do that immediately? Why don't we put a date on it and say to a couple of companies "come on in here and bid and let's get started"?

Is that in contemplation?

Dr. GLENNAN. Not in this agency, Mr. Fulton. I think you must recall that ARPA has a strong program in the active communications repeater satellite.

Mr. FULTON. I know that, but I am trying to get some way to get these things in operation, because to me it may appear that they are trying to get too sophisticated and too complete a system when, as a matter of fact, our security would demand that we go by steps doing what we can as we can, and with partial protestations that can be built into satellites rather than something that does everything we want as if it is a later model automobile.

Dr. GLENNAN. Mr. Fulton, I think as you hear the backup for the various research and development programs, some of the answers to your questions will fall out naturally.

Mr. FULTON. Are you sure this is enough money?

Dr. GLENNAN. I responded a little earlier to Mr. Miller that I would not be foolish enough to say that one could never use another dollar. At the pace at which we are presently going in our ability to build the kind of an organization that is necessary to manage this size program. At the rate at which we can acquire and sensibly use information, I think that at this stage of our development, this is a reasonable budget.

If we get some breakthroughs and develop some capabilities faster than I now think to be the case, we will be the first to come back through the normal channels and ask for more money, sir.

Mr. FULTON. What is the amount of your original budget appropriation request for fiscal year 1960 to the Bureau of the Budget and how much was it cut?

Dr. GLENNAN. Could I supply those figures to you? I had them before, but I don't have them with me today.

Mr. FULTON. Will you also then insert in the record the various programs that were under consideration and that you had recommended as high priority which were cut under that procedure. I would like information on this particular angle.

(The information is as follows:)

The submission of the formal National Aeronautics and Space Administration budget was made to the Bureau of the Budget with an overall figure of $523.6 million. The Bureau reduced the NASA budget by $38.3 million, to the present 1960 figure of $485.3 million.

No high priority programs were cut out under this procedure.

Mr. FULTON. At the present time how do we stand in relation to Russia on its programs? We have had that question asked previously. I wish you would now bring us up to date. Who is ahead, who is behind, and does this program in my language permit us to leapfrog Russia on progress in the ICBM field particularly, the IRBM field, and these various kinds of satellites as well as man in space and possibly a trip to the moon?

Where do we stand? If you could sum it up, I would like to hear you, and then the effect of this program for fiscal 1960, generally what does it do in relation and proportion to what the Russians effort is. That is all.

Dr. GLENNAN. Would you like me to try to answer that series of questions?

Mr. FULTON. That is what people are asking me, and I certainly would like to have you for good authority.

Dr. GLENNAN. Well, I am in the same boat. A lot of people ask me the same questions, and I have very much the same source of information you do.

Mr. FULTON. What does this program do in your estimation?

Dr. GLENNAN. Since I don't know how much money the Russians are spending on it, but have an idea that it is a sizable amount, and as I don't know how many people they have on their program, but I suspect they have an adequate number, I can only base my judgment on what I know from conversations with our people in the scientific world, from the reports that one does get from writings that are published in Russia, from an examination of the results that are published to date by the Russians through varied channels.

Mr. FULTON. You see you are in a peculiar position to evaluate this for our American people because not only are you head of NASA and have all of these people advising you from the President down, but also you have been to Russia with that educational group studying their educational system. So you are in a peculiar position to be able to give us a valid judgment. I think your views should be noted.

Dr. GLENNAN. My judgment, for whatever it is worth, is that in the single field of propulsion, I believe the Russians still exceed our capability. It is my belief that within a year and a half we will have a capability that essentially matches their present capability. Whether they will have decided in the meantime that they need to have a larger thrust, I don't know.

But if they did, it is possible that they would still be somewhat ahead of us in total propulsion capability.

The program which we have worked on and which this budget starts and helps to support in that particular area, along with the program that ARPA is supporting—gives us a capability as great as any we will need within the next 6 years and probably a very substantial capability within the next 3 years.

In other fields of data acquisition, the interpretation and analysis of the information that have been acquired from the shots, it would seem that we have done as well as they have if not better. Maybe it is because we have been willing to publish more than they have, but somehow or other in a race for the minds of men the world over, I don't believe that they would have been holding back very much of this sort of thing if they really had it. I think that my scientific colleagues here, Dr. Dryden in particular, can perhaps give you a better evaluation of the quality and quantity of the scientific information that has been retrieved from our satellites vis-a-vis their satellites.

Mr. FULTON. Actually isn't it a fact that on telemetry and tracking equipment, because we have a worldwide system not only with ourselves, our own stations, but with our free world allies and friends, we greatly exceed the Russians, don't we?

Dr. GLENNAN. We certainly would have more equipment, more stations, than they, although their country, as you know, spans almost half the world, some 11 times our own.

Mr. FULTON. Have you started negotiations yet to buy Christmas Island? I think that is the best station that we could have in the Pacific. Why don't we buy it from Britain?

Dr. GLENNAN. No, we have not.

Mr. FULTON. Why don't you start it?

Dr. GLENNAN. We are in the process of laying on a thoroughgoing study of this equatorial launch site. I am sure this is what you are referring to.

Mr. FULTON. On the other side of the world, maybe, don't we have a second equatorial one?

Dr. GLENNAN. I think first we must decide as best we can, with all of the interested parties around the table, what the real reason for an equatorial launch site may be. When one totes up the total cost of a permanent installation as against perhaps a shipboard installation of the type that we have used in the Eniwetok tests, at least

in the earlier Eniwetok tests, one can then come to the kind of conclusion that would make sense.

Mr. FULTON. With British cooperation you could possibly not expend too much money and would have available such a site as Christmas Island if we agreed to have——

Dr. GLENNAN. This certainly may be possible.

Mr. FULTON. I have often wondered why don't you try for a stationary floating platform at the first point of Aries, where the sun crosses the Equator, at the vernal equinox, because that is the starting point of the measurements of everything we have in astronomy? Why don't you put a platform there so you can make actual observations, both visual and micromic.

Dr. GLENNAN. I couldn't answer that question. Perhaps Homer Newell could.

Mr. FULTON. We could get an exact figure on everything we are talking about. Everything we are doing in astronomy has to be related to that point and nobody is there. As it is moving every year, you could probably move it in the direction it is going. Had you thought of that?

Dr. GLENNAN. I suspect our scientists have, Mr. Fulton. When we discuss the space science portion of this program, perhaps you will get a better answer on it.

Mr. FULTON. If you would expand in the record what you feel about the progress of the program, and the last question is: Will this program leapfrog the Russians, or just keep us even with them, or just keep us slightly behind them in the next year or two?

Dr. GLENNAN. We are not about to be satisfied with being slightly behind anybody. The extent to which a program financed as this one is will allow us to leapfrog the Russians or anybody else is not very easy to prognosticate when we really don't have as much information as we might like on their program.

Mr. FULTON. Your policy is to get ahead of the Russians with this program?

Dr. GLENNAN. Our policy is to lay on a program in our activities in this new environment just as fast as reasonably we can. If this will allow us to get ahead of the Russians, and I think it should do this, then I shall be very satisfied that I took on this job.

Mr. FULTON. That is all.

The CHAIRMAN. Doctor, would you mind reading the list of scheduled shots that you referred to a while ago?

Dr. GLENNAN. This is for an executive session. We have that for you, sir.

The CHAIRMAN. It is in executive session?

Dr. GLENNAN. Yes, sir.

The CHAIRMAN. You referred to the priorities of certain programs you would give us. Do you have that in list form that you could give to the committee?

Dr. GLENNAN. I am not sure if I understand your question, sir. I think that in the presentations which will come in support of each of these programs, each of these requests for money, the detailed breakdown here, you will get a picture of the progress in each of the programs and the planning.

The CHAIRMAN. I had understood that, but you referred to some priority of programs.

Mr. FULTON. There has been a calendar already issued to the newspapers and magazines from your agency. I would like to have that.

The CHAIRMAN. Is there any objection to this committee having it?

Dr. GLENNAN. None whatsoever.

The CHAIRMAN. Do you have it available?

Dr. GLENNAN. I do not have that available with me at the moment, but you will get a complete calendar which we would prefer to give you in executive session, Mr. Chairman.

Dr. DRYDEN. We prefer to give it in executive session merely because we do not like to tell the Russians all about our program and we don't know a thing about theirs. If the committee wishes to take the responsibility for full disclosure, then I think we would be bound by your decision.

The CHAIRMAN. Doctor, let me say this on behalf of the committee. The committee has followed meticulously the suggestions of the Department as to what is secret, what is executive, and what is available to the public. As far as I know there has been no infraction by any member of this committee.

Dr. DRYDEN. It is not classified information. It is a matter of public policy whether you want to state in detail for 3 years ahead what NASA intends to do. We would very much like to see the same information from the Russians. We don't have it.

If you want to give it to them, and authorize us to do that as a matter of public policy, we will be governed by your decision.

The CHAIRMAN. At this point, then, if there is no objection, we will go into executive session——

Mr. FULTON. Will you yield?

The CHAIRMAN. I have given the floor up here.

Mr. FULTON. I had it previously. It has been given to the newspapers and the magazines seriatim and serially.

Dr. DRYDEN. It has not.

Mr. FULTON. There has been some given, because I have seen them and I have seen big announcements from some newspapers on what is going to happen.

Dr. DRYDEN. There are statements made by contractors to NASA—we attempt to keep this under control—about immediate shots. But you are talking about the program for 3 years ahead. We would prefer, if it is left to us, not to give it in open session.

The CHAIRMAN. The committee then will go into executive session, and after the test is given, if it is advisable, the committee will release it——

Mr. FULTON. Would you just yield until we finish this? I am not quite through.

The CHAIRMAN. Mr. Miller?

Mr. MILLER. I was just going to suggest we have some members of the committee who haven't had an opportunity to question Dr. Glennan, as others of us had. Why don't we get rid of this questioning and then go into executive session after they have an opportunity to have the same privilege as some of us have had.

The CHAIRMAN. I think we all should have a chance. Mr. Ducander was going to get a clock for the committee so that we could follow the rules of the Committee on Foreign Affairs. That is, each member of the committee would be limited to a specified time. How is that clock situation developing?

Mr. DUCANDER. I am checking on the price, Mr. Chairman.

The CHAIRMAN. Check on the character and get the same kind they have on the Foreign Affairs Committee so we can tell the same time and follow the same rules.

Mr. CHENOWETH. Mr. Chairman, what kind of a clock do you propose to get? We have got a clock on the wall everyone can see right in view here.

Mr. DUCANDER. This apparently is a two-faced clock. You can see it from any angle.

Mr. FULTON. Does it tell two times or just one?

Mr. DUCANDER. It tells the same time on each side.

Mr. CHENOWETH. We can only hear one side at a time.

Mr. FULTON. Mr. Chairman, on this policy question, could I ask the doctor seriously to supply for the record what you think advisable within your discretion that should be a public calendar, rather than shut the thing off completely as if there is nothing going to be given, because I am going to put the Library of Congress on picking up from the newspapers and I will put it in the record.

Dr. GLENNAN. We will be glad to do that for you.

NOTE.—This information was given in executive session of the committee on April 20, 1959.

Dr. GLENNAN. I want to make one point with you, Mr. Fulton. I suspect that there were many Members of Congress as well as a great number of people in the general public who raised serious question about the manner in which we talked about what we were going to do in the Vanguard program, and our failures caught up with us and we had——

Mr. FULTON. So did your successes.

Dr. GLENNAN. We are awfully glad when we get those successes, but the business of trying to lay on a program and pinpoint it as to dates puts our people under the kind of pressures and puts our Nation under a cloud of boasting about what it is going to do.

We are glad to tell you what we are trying to do, what our objectives are, and this will come out of our detailed effort.

As to the laying on of a schedule of shots, we will be glad to give you for the record what we think ought to be said about it.

Mr. FULTON. Might I point out to you the policy of the space statute which was passed by Congress last year which instructed the agencies of this Government to make available to the scientific communities of the world all information unless we in Congress decided, or the security agencies decided, that it should be withheld. That is exactly the opposite policy that you are speaking of.

Dr. GLENNAN. I think not, sir. I think we would follow that exactly. We would ask you to determine how much you are going to say about what you are going to do in the future as against what you have done.

The CHAIRMAN. Mr. Bass, do you have any questions?

Mr. BASS. Mr. Chairman, I just want to say for the record, speaking only for myself, that I agree 100 percent with what you say, Doctor. I think it would be very foolish for us to make public a long-range program of what we intend to do. I think what happened in these Vanguard proposals is a pretty good indication as to why.

Mr. MILLER. Will the gentleman yield? I would like to support his position.

Mr. FULTON. I am talking about things——

Mr. MILLER. Mr. Bass has the floor.

Mr. BASS. I yield.

Mr. MILLER. I would like to support your position on this, Mr. Bass. That is all.

Dr. GLENNAN. Thank you, sir.

The CHAIRMAN. Any further questions, Mr. Bass?

Mr. BASS. Nothing further.

The CHAIRMAN Any further questions? If not, we will go into executive session at this time. We will have to ask all of our guests to leave except those who are qualified to stay.

(Whereupon, at 11:22 a.m., the committee went into executive session.)

AFTERNOON SESSION

The CHAIRMAN. We will now go into open session.

STATEMENT OF DR. ABE SILVERSTEIN

Dr. SILVERSTEIN. You will recall, Mr. Chairman, in Dr. Dryden's presentation he mentioned the sum of $333 million relating to our research and development program in space flight development.

I and the group of technical people we have with us here today will speak to this part of the program initially.

Summarized on this chart are the principal elements in the program. First, an item called "Aircraft missile and space craft research" for $30,020,500. This includes the support within our laboratories for the research and development program items relating to equipment, supplies, and contractural relations to be expended there. Also it includes the item we have for the inhouse research at the Jet Propulsion Laboratory, and our research contracts. These three items are included to add up to $30 million.

The second major heading is "Scientific Investigations in Space"—the sum of $46,743,000. We will have a speaker later to discuss the separate programs within the scientific investigations and go into this in considerable detail.

The next item is for scientific applications investigations, for $15,500,000. Here we discuss the meteorological program, the communications program, the applications of satellites to useful purposes. Again we will have a speaker later who will go into detail on it.

The next item is the "Space operations technology," in the amount of $73 million. $70 million of this $73 million relates to our effort in manned satellites, and you had a few glimpses of some of the early work we are doing in the film you have just seen. Again we will give you a detailed presentation in this area.

"Space propulsion technology," $52,200,000, takes care of the work we are doing in the large engine development, in the million to a million and a half pound rocket, the high energy propellent rockets, and solid rockets. Again we propose to discuss some of the essential elements of this program in great detail.

The space systems technology relates to some advance work we are doing toward the development of the newer vehicle systems of the future, and the recovery of space objects so that we can use them over again, We will have someone to discuss this item later.

The tracking and data acquisition for $11,500,000 relates to the operation of the worldwide tracking network that we are setting up, the handling of the data, and the taking care of advanced technical developments in this whole area.

The last item, which is the largest you see on the list, for $99,100,000, takes care of the work we are doing in advanced vehicle development. As you know, the full program and the future of our program rests on the rapid development of higher booster capability. It has been pointed out many times in these discussions that this is the area in which we fall behind the Russians.

It is up to us to move this program along with all the speed that is possible.

In our program, which, as you know, is a national program, that has been correlated with the Defense Department, we are setting about to develop a series of new vehicles of gradually increasing capability. The first of these vehicles was mentioned this morning. It was called the Scout.

With the Scout we are trying to get a vehicle which can be an all-purpose vehicle to carry some small payloads which we can develop and build at a much more economical price than we have been paying for boosters of comparable capability in the past. And this will also be a vehicle which we feel will be a great deal more reliable than some of the equipment we have been using.

It is a solid booster, and since we are on this object now and it does represent the keystone of our program, we will start our technical discussions by a discussion of the Scout in the vehicle program and continue with some of the other elements of the vehicle program.

Mr. Chairman, I would like to have Mr. Stoney, who is with our Langley Laboratory, make this presentation.

STATEMENT OF W. E. STONEY, JR.

Mr. STONEY. You have heard and are going to hear a lot in these hearings about the larger and larger boosters needed for the large payloads of the future. There still remains a place, however, for a relatively small vehicle. By "relatively small," we mean a vehicle capable of placing about 200 pounds in orbit about the earth.

Being relatively small, it will be relatively cheap, and this cheapness gives it a versatility. You can afford to fly it with maybe one or two different experiments aboard and tailor your flight paths to fit those experiments exactly, rather than compromise their requirements for four or five different experiments.

The Scout, which I am going to describe, is the vehicle we have designed to do this job. I can best describe it to you by showing you

this model. It is a vehicle about 70 feet high or nearly the same size as the Vanguard. It weighs 36,000 pounds at takeoff, as compared to the 23,000 pounds of the Vanguard. It is made up of four solid-fuel rockets, as we have indicated with the different colors here in the model. Each one is a different stage. This last stage is a rocket with a payload on top of it, indicated by the metal cap.

In the way it will operate, the first stage fires and takes the vehicle off the ground. After the first stage burns out, the second stage is ignited and the first stage is left behind. After the second stage has finished its firing, the third stage fires and the second stage is left behind. During this period we also get rid of this shield that has been around the upper stages to keep it from getting too hot.

After the third stage has finished its firing, the two stages remain attached and continue on to the peak altitude. During this period little rockets at the rear end of this third stage orient the missile into a horizontal position. When the peak altitude has been reached, these little red things—I don't know whether you can see them or not—little spin rockets, spin the last stage rapidly. Then it is fired and separates from the third stage and goes into orbit, and the third stage falls back toward the earth.

This is what would be done if we were firing for an orbit. This vehicle also has a capability of doing very high-speed reentry tests, which you will see in a minute.

In that case we would orient the vehicle pointing toward the earth and fire right back in.

This vehicle uses solid fuel, and as Dr. Silverstein said, one of its features, we hope, will be reliability. NASA has had considerable experience in the last few years with solid-fuel rocket test systems and found them to be reliable in comparison to liquid systems.

In addition to being reliable, operationally they are simpler than liquid systems. The countdown for example for a solid-fuel system is a matter of minutes compared to the hours required for liquid fuels.

NASA's experience with these systems has been based on this series of rockets here, which have been flown for research purposes by the Langley Laboratories for the last 14 years. I have just shown some of the later vehicles here on this chart. The Scout is shown here on the bottom. With these vehicles, as you can see, we have attained speeds of 10,000 and 12,000 miles per hour. These vehicles have been used for heating tests on ICBM type warheads such as the Polaris, and stability tests with the same type of objects.

The Scout, which has a speed potential of nearly twice our latest five-stage vehicle—more than twice, as a matter of fact—will enable us to test the most advanced type of ICBM warheads contemplated for the near future.

It also will give us a greater payload capacity. These vehicles shown here had only a payload of capacity of about 20 pounds. The Scout will raise that capacity at the same speeds to the order of 100 to 200 pounds, allowing us to make much more comprehensive and detailed tests of this same type of thing.

Another area in which these vehicles were used is in the high altitude probing of the atmosphere about the earth. This five-stage system here was used in the Air Force's Project Jason, which was connected

with the Argus project. You may have read something about the explosion of the atom bomb at high altitudes recently.

The Scout will have the same sort of capability and will be used in the same way, but instead of putting 50 pounds to 500 miles, the Scout will be able to put a hundred pounds to 5,000 miles, or 50 pounds to about 10,000 miles.

Of course one of the most interesting uses of the Scout will be to orbit scientific payloads and other types of payloads into orbits about the earth. We have shown the potential of the Scout in this respect on this chart.

We have chosen 100 pounds of instruments as being perhaps a minimum payload that you would be interested in doing in the type of advanced work that is required these days. We have shown the earth here surrounded by the Van Allen radiation belt, which the early satellites have given us a picture of. And we have shown two types of orbits—a polar orbit shown in the blue color, and the west-to-east orbit in yellow.

The polar orbit does not take advantage of the earth's rotation. However, it is valuable in many ways and for many experiments because the satellite can be seen and can see all parts of the earth's surface during its travels. This would be valuable in communications or cloud cover experiments or reconnaisance type experiments.

In this type of orbit we have the capability of 1,200 miles if we fly in a perfectly circular orbit. If we wish to go up higher, we shoot for a lower perigee, and then instead of 1,200 miles, can achieve 8,000 miles away from the earth at its farthest distance.

If we take advantage of the earth's rotation and can achieve a 200 mile perigee, we can get 15,000 miles outside the limit of the earth. If we plan correctly, we can get orbits anywhere between these two extremes.

Thus you see we can cover rather well the very interesting area around the earth indicated by the early satellite experiments.

In addition to the uses and the scientific investigation of outer space, it has a payload capability of allowing us to make early tests on systems that will be used in the really large satellites of the future—systems such as stabilization mechanisms which these larger satellites must have.

At the present time the status of the Scout is in early design. We expect to make the first flights of the test vehicles in early 1960. The fiscal 1960 funds call for $2 million to finish the test phase of the Scout program, and when the testing is finished, we expect the additional vehicles to cost on the order of half a million dollars apiece, which can be compared with numbers of about two to three times that cost for the liquid-fuel boosters of the same type of capability.

In summary, I have shown you the NASA Scout vehicle, a vehicle being designed to provide NASA with a highly reliable, versatile, and relatively cheap booster system, capable of extending the scientific investigation of space begun by the Vanguard and the Explorer, capable of being used in the development of systems of larger satellites of the future, and capable of extending our reentry testing capability to the extremely high speeds that will be required by the ICBM's of the future.

Thank you.

Dr. DRYDEN. May I mention, Mr. Chairman, that the Air Force has an interest in this vehicle and are represented in its planning. They are planning to use quite a number of these vehicles in their programs.

Dr. SILVERSTEIN. The second phase of our vehicle development involves a vehicle called Delta. The Delta vehicle is basically a modification of the type of vehicle we used in some of the moon probes. It uses the Thor as a first stage booster. It has the Vanguard second stage as its second stage, and the same for the third stage.

It differs from the Pioneer vehicles we used with the same general combination of vehicles in that we have put advanced guidance in this Delta vehicle so that we hope that when we fire to the moon again, instead of coming within 37,000 miles, that we can come to any predetermined distance we care to. Also, we have improved the general method of spin-up and separation of the stages.

This vehicle has been contracted for and will be available later in the year as a part of our program.

The next major step in our booster program following the Delta is the so-called Vega vehicle which I mentioned this morning briefly in presenting the chart on our program. I would like to ask Mr. Rosen to describe for you the Vega vehicle.

STATEMENT OF MILTON ROSEN

Mr. ROSEN. Mr. Chairman, members of the committee, one of our problems with the present generation vehicles is that each one of them is designed principally for one specific mission. As a result we have followed a rather familiar pattern. We have had a few firings of one type of vehicle. Some of these have been successful. Some unfortunately have been unsuccessful.

Then we have called upon another vehicle to take the stage. In this situation there is no opportunity to develop a high degree of reliability in any one vehicle of the various types.

Although in all of these vehicles we test everything we possibly can on the ground before firing, nevertheless the final proof comes in the flight. It is during flight that you learn many of the things that you could not have foreseen before.

The only practical way that we know of to attain a high degree of reliability in a vehicle is to use the vehicle for a large number of missions; to fire the same type again and again and again. We are confident that we can design vehicles of this type, vehicles that are versatile and that can do most of the space flight missions that we wish to attempt in a 2- to 4-year period.

We will be generating a series of these vehicles of increasing payload capability, and all of them will be capable of performing low and high earth orbits, of performing highly elliptical earth orbits, of sending payloads out to the moon, and the planets.

One of the earliest of these vehicles is called Vega. The reason it is one of the earliest is because it is based very heavily on existing technology. To be more specific, on the Atlas technology.

The main part of the vehicle is an Atlas, an Atlas series D vehicle. The Vega will include sometimes one additional stage, and sometimes two.

Here is a comparison of the existing Atlas and the three-stage Vega. As you can see, the principal change to the Atlas is that the upper tank is extended to the full 10-foot diameter of the body so that it can support a 10-foot diameter second stage. Here is the second stage and the small third stage.

Most of the vehicle is still Atlas. As you can see, it is slightly taller than the Atlas, 96 feet as opposed to 82. It has the same diameter.

This is the engine of the second stage or new stage. Here again we are drawing upon technology that we know. This engine is a modification of the Vanguard first stage engine. Of all the Vanguard engines, this one has the best record. It has performed successfully in its last seven fights. Some of these flights were marred by later stages. The record of the first stage engine has been excellent.

For Vega, we will modify it by extending the nozzle so that it can operate better at high altitudes, and we will give the engine the capability of being started remotely. These are the major modifications. The thrust chamber, injector, the turbine, and the pumps are identical to what is now being used in Vanguard.

The engine is shown here installed on the tankage of the second stage.

For missions where we would want to place a payload in orbit around the earth, we would probably use only two stages. But where we wish to send something to the moon or to the planets, we can increase the payload capability by carrying a third stage.

When we do this, we want this third stage to operate 2 days later, in the case of the moon; in the case of a planet, several months later. We therefore use storable liquid propellants, as opposed to the cryogenic propellants like liquid oxygen, which would vaporize readily at room temperature.

These storable propellants can be kept in the tanks for several months and the engine can be started successfully

This is a small stage of about 6,000 pounds gross weight, and the payload would be carried on top of this stage.

This chart shows the trajectory or path into orbit of the two-stage Vega. It starts at takeoff with the normal start of an Atlas, in fact, we can use an existing Atlas launch site. The three Atlas engines, two shown here and one here, ignite at takeoff and propel the rocket up to this point.

Then the boost engines drop off. This is normal Atlas operation. Then the sustainer engine continues through the second red segment.

At this point the Atlas is finished burning and is jettisoned. The Vega or second stage coasts up to a 100-mile altitude.

Here the Vega is fired for the first time and it gives enough speed to the vehicle so that it can coast out to a 300-mile altitude. Then we see one of the essential features of Vega—that the second stage has restart capability. In other words, it can be started, shut off, and started again.

It is restarted at the 300-mile altitude to give the vehicle sufficient speed to maintain it in a 300-mile orbit. If we did not fire again, the stage would drop back to the 100-mile level and we would have an elliptical orbit.

We are going to show you a few typical uses of Vega, not that any of these are, as yet, firm programs, but rather illustrate the capability of the vehicle.

Vega can place between five and six thousand pounds in a low orbit around the earth. With that capability we can envision placing two men in a space capsule and maintaining them in orbit for a period of 2 to 3 weeks with sufficient provisions and with instruments so that they could make observations.

Another use of Vega would be as an observer of the moon, where we would place the final or third stage in a close orbit around the moon. We would have a television camera in the payload that would scan the surface of the moon and transmit information back to a receiving station upon the earth. By this means it would be possible to map the entire lunar surface.

Finally, the vehicle has the capability of sending sizable payloads, of the order of 1,000 pounds, to the vicinity of the planets, the near planets—Mars and Venus. This is admittedly an artist's conception of the vehicle passing by Mars as seen from its outermost moon, Deimos.

We are obligating, in fiscal year 1959, $22.8 million to Project Vega, and we are requesting in fiscal year 1960 $42.8 million for continuation of this program. These funds are for the development and procurement of second and third stages, for the procurement of Atlas boosters, for the development and procurement of ground equipment, and for the field operations necessary to launch these vehicles.

Thank you.

Dr. SILVERSTEIN. Mr. Chairman, on this program we have, the next item is Project Centaur. We will skip that one if we may for the time being—this is the one we would like to have in closed session—and go to the next item, the million-pound single-chamber rocket. I will ask Mr. Hyatt to make that presentation.

STATEMENT OF ABRAHAM HYATT

Mr. HYATT. Mr. Chairman, gentlemen, our most ambitious undertaking to date in the field of rocket engine development is the 1-million-pound thrust, single-chamber engine. Actually this engine is capable of being developed to produce a million and a half pounds thrust.

In the next few minutes I would like to review for you, very briefly, the history of the engine, describe its operation, and also indicate to you a preliminary design of a vehicle based on this engine.

Early in 1958 the Air Force conducted studies to determine the feasibility of a large-thrust rocket engine. When the National Aeronautics and Space Administration was established, it undertook the sponsorship of the development of this engine. On October 12, 1958, several manufacturers were asked to submit proposals in a design competition for this engine.

The NASA received these proposals on the 24th of November of last year, and after an intensive evaluation, a winner was selected and publicly announced on the 12th of December.

A definitive contract was signed on the 9th of January of 1959 with the Rocketdyne Division of North American Aviation. The contract

calls for the development of this engine to a certain specified preliminary flight rating test to be accomplished in a matter of 4 to 6 years.

The price of the contract is approximately $102 million.

Next, with the aid of this model, I shall describe how the engine operates. First, I shall indicate the major components of the engine. This portion is the thrust chamber. From here down is the nozzle. The apparatus on this side is the turbopump. Then we have many lines and valves. The device along here is called a gas generator.

At this point is where we attach the engine to the missile superstructure, and the long cylinders on the side are the actuators which move the engine back and forth.

For clarity I will start describing the engine operation beginning with this device, which is the gas generator. By the way, this engine is fueled with liquid oxygen and a petroleum fuel which is very similar to turbojet engine fuel. For rockets the fuel is called RP–1. I will refer to it a number of times.

The color of the lines—green is for the liquid oxygen and the red is for the RP–1. We bleed oxygen and RP–1 from the main lines into the gas generator. It is a combustion chamber where the propellants are converted to hot gases.

The hot gases are then piped to the turbine and furnish the power for it. The exhaust gases are carried through this structure back into the nozzle and exhausted through the bottom of the nozzle.

The turbine is mechanically connected to two pumps. The upper one pumps liquid oxygen, and this one, between it and the turbine, pumps the fuel. The liquid oxygen comes through an opening from the tanks up above, and the pump then moves the fuel and raises its pressure.

Similarly, two more lines come from the tanks above with fuel and they enter these two openings.

Both of the pumps not only move a large quantity of liquid, but they also raise the pressure of the liquids to several hundred pounds per square inch. This pressure is necessary in order to overcome the losses in the various passages in the engine, as well as to force the liquid into the combustion chamber which operates at a high pressure.

As the liquid oxygen leaves the pump it goes through these two green lines into the injector head. I will describe what happens there in a moment.

From the fuel pump the fuel leaves through two lines and enters a manifold here. The fuel is used to cool the engine. It enters here and is distributed to a multiplicity of small tubes and actually travels down the full length of the engine and back up again thereby cooling the chamber.

Then it goes into the injector head also. The injector head may be thought of as a circular disk with many small holes in it, very similar to an ordinary shower head. In fact, some designs are called "shower head" injectors.

Through a number of these tiny holes, the liquid oxygen is forced and through others the RP–1. As they enter the combustion chamber they are vaporized and burned, and the gases travel down through the throat of the chamber and on down the nozzle and furnish the thrust to the engine.

On top here is a gimbal point. This is a mechanism so designed that the entire engine that you see here can be moved about that point in any direction to furnish stability and control to the whole vehicle.

These actuators are actually hydraulic cylinders which take the command signals from the guidance system and move the engine in such a direction as to move the vehicle in the desired direction.

The gargantuan size of this engine can be seen by comparing it to the size of this man, which is to the same scale as the engine. As you see, the engine is more than three times as high as the man, and it is more than twice the height of the man across the bottom of the nozzle.

You may be interested in some numbers about this engine. The turbine develops more than 50,000 horsepower. These two pumps have the combined capacity to move 6,000 pounds of liquids a second. By way of comparison, an average automobile at 60 miles an hour uses one one-thousandth of a pound a second.

In other words, we move enough fuel here to supply 600,000 automobiles going at 60 miles an hour.

The temperature in the engine is 5,500°. Again, by way of comparison, stainless steel melts at about 3,000°.

Before I complete the discussion of the engine itself, I would like to show you a picture of the kind of test stand that is required to conduct engine tests. This is stand 1–A at Edwards Air Force Base. For testing the engine, we do not require the superstructure that you see here. It will be removed and replaced by a different kind of structure.

The size of the structure can be seen as compared to the automobile that is parked below.

The engine I have described will be used to power future generations of vehicles. In my next chart I would like to show you a preliminary design of a vehicle that is based on this engine. We have given it the name of Nova.

The first stage of this vehicle is powered with four of these engines at 1½ million pounds of thrust, adding up to a total of 6 million pounds of thrust for the first stage. The second stage is powered with a single engine such as this.

Because of the fact that this stage will operate at very high altitudes, the actual thrust that can be developed with the same engine in vacuum is higher. It goes up to 1,700,000 pounds.

The upper stages are assumed to be powered, at least for this preliminary design, with high energy fuels, liquid oxygen and liquid hydrogen; and their thrusts and the weights are as you see here.

You can see the size of this vehicle in comparing it to the size of a 6-foot man here at the bottom.

On the right side of this chart we see some of the missions that a vehicle of this kind can accomplish. First, I would like to describe this mission. It is an orbital mission showing the load this vehicle could lift to a 300-mile high orbit above the earth.

The load is 150,000 pounds. A weight of this kind is sufficient to accommodate a rather fully equipped manned laboratory.

With this same vehicle we could also place as much as 43,000 pounds in an orbit about the moon. This weight, too, is sufficient to accommodate a manned expedition to orbit the moon and make many important observations and measurements.

We can also send as much as 4,500 pounds to a soft landing on a near planet. In addition to the payload, weight has allowed for an energy supply to retard the speed of the payload and land it softly on the planet Mars.

The payload provides sufficient weight so that we can put enough instrumentation, communications systems, and power systems to permit transmission of very important measurements back to earth.

We could land as much as 20,000 pounds in a soft landing on the moon. But perhaps most interesting of all is that this is the first vehicle we have considered which could take off from the earth, travel to the moon, make a soft landing, take off from the moon and return a manned vehicle to a soft landing on the ground.

The CHAIRMAN. How would you get off of the moon after you have made a soft landing?

Mr. HYATT. We have allowed enough weight, in the load that lands on the moon, for a small rocket propulsion system. When the expedition is ready to leave, the vehicle is launched from the moon by the rocket engine into a path that leads us to the earth.

After that there is another power source in it to retard our speed, which is necessary to do in order to come around into a proper orbit around the earth and then settle back down through the atmosphere to the ground.

This is the amount of weight we would return to the earth, and we believe it is a minimum required to return a man to the earth.

It is interesting to note that in order to accomplish this, we start off with 4,800,000 pounds from the earth and we return to the earth a weight of 2,100 pounds.

This vehicle will give us a capability far beyond any of the other vehicles that we have considered to date. To carry on this program we are requesting $30,200,000 in fiscal year 1960.

Thank you.

Mr. MCDONOUGH. That is in addition to the contract already awarded to North American?

Mr. HYATT. No, sir. The contract was $102 million, but it carries for a period of several years. For the fiscal year 1960 we need $30.2 million toward that $102 million.

Mr. MCDONOUGH. The contract with North American is the development of the 6-million pound thrust that you have on this chart?

Mr. HYATT. The contract to North American is to develop this engine, but not any of the tankage or anything else—just the engine.

Mr. MCDONOUGH. But your chart shows three of those engines there.

Mr. HYATT. Yes, sir, four in the first stage and one in the second stage. We can only see one, two, three. A fourth one is behind this middle one.

Mr. MCDONOUGH. Yes. Show me what stage of the rocket you would land on the moon with and depart with.

Mr. HYATT. This is a portion here that is not shown in detail. Actually there are a total of seven stages required. We would have to fire up seven times. The portions that would land on the moon are contained in this upper portion.

Mr. MCDONOUGH. And the portion you depart from?

Mr. HYATT. Is also in there, yes, sir.

Mr. RIEHLMAN. How much work has been done on that last stage in the field of research?

Mr. HYATT. Directly toward this project, not a great deal. But cumulatively, many aspects of the space program are being carried on which will eventually contribute to development of this stage.

Mr. RIEHLMAN. That is some time off, isn't it?

Mr. HYATT. Yes, also the work being conducted in Project Mercury, the design capability that is learned on that project, will also contribute to the design of a vehicle for a moon expedition.

Mr. RIEHLMAN. That would cut down the time considerably, wouldn't it?

Mr. HYATT. Yes.

The CHAIRMAN. Mr. Hyatt, may I ask you this question. Why do you call that Nova?

Mr. HYATT. It is just a name that was selected. Nova, in astronomy, denotes a star which undergoes a sudden and enormous increase in brightness.

The CHAIRMAN. Named after the star?

Mr. HYATT. Yes, sir.

Dr. DRYDEN. All the vehicle names are from the stars. Vega is a star.

The CHAIRMAN. Let me ask you on this point. You have a thrust of 6 million pounds, but it is a thrust of a vehicle there with four separate chambers.

Mr. HYATT. Yes, sir.

The CHAIRMAN. Each one of those will estimate about what—1,225,000?

Mr. HYATT. 1,500,000.

The CHAIRMAN. 1,500,000 pounds thrust. But the total is 6 million. Now you go to your second stage. You have got 1.7 million pounds thrust. Is that in addition to the 6 million?

Mr. HYATT. Yes, sir, that is in addition to the 6 million.

The CHAIRMAN. So that will give you a total of 7.7 million. Is that right?

Mr. HYATT. Yes, but they don't fire at the same time.

The CHAIRMAN. But you have to have that thrust.

Mr. HYATT. We have to have that thrust, that is correct.

The CHAIRMAN. And you have to have 325,000 pounds more, and 80,000 pounds above that.

Mr. HYATT. And then some more above here.

The CHAIRMAN. But you don't show how much more above that.

Mr. HYATT. They get smaller each time. We just didn't want to put all this information on one chart. We have all those numbers.

The CHAIRMAN. You would have to have at least 8 million pounds thrust, perhaps more.

Mr. HYATT. If you wanted to add it all up, yes.

The CHAIRMAN. If you are talking about Nova, you are talking about 8 million pounds thrust.

Mr. HYATT. We don't normally refer to it that way, sir. We always refer to the amount of thrust that is fired at one time.

The CHAIRMAN. The greatest amount from the greatest section of it, or stage of it.

Mr. HYATT. Just to clarify that point, if we, for example, said that this vehicle needs 8 million pounds thrust, one might think we put it all in one stage and fire it.

We could not achieve the same results with a single stage with 8 million pounds thrust as we achieve with this multistage vehicle. It just doesn't work out that way.

The CHAIRMAN. This is a consecutive operation?

Mr. HYATT. Yes, sir.

The CHAIRMAN. A man serving time in a penitentiary serves consecutive terms there, and it makes it longer.

Mr. HYATT. Yes, consecutive when referring to multistage rockets, not concurrent.

The CHAIRMAN. How large an engine would Nova be?

Mr. HYATT. You mean the height?

The CHAIRMAN. Yes.

Mr. HYATT. Between, say, 250 and 300 feet.

The CHAIRMAN. How wide at the base? Would it be about 15 feet?

Mr. HYATT. No, sir, it is about 35 to 40.

The CHAIRMAN. Each engine is about 15 feet.

Mr. RIEHLMAN. What would the total weight be?

Mr. HYATT. The total weight is 4,800,000 pounds on this particular design.

Mr. RIEHLMAN. The total for everything?

Mr. HYATT. For everything. That is how much we launch off on the ground.

The CHAIRMAN. Loaded?

Mr. HYATT. Loaded.

Mr. MCDONOUGH. The escape velocity of the moon is less than the escape velocity of the earth, isn't it?

Mr. HYATT. It is, yes, about one-fifth.

Mr. MCDONOUGH. You calculated that the amount of propellant you have in that upper stage is sufficient for escape velocity of the moon?

Mr. HYATT. Yes, we did.

Mr. MCDONOUGH. And you also calculated that the vehicle that you come back in is designed so that it will not burn up when it comes into the atmosphere?

Mr. HYATT. Yes. Of course you could think of it as a design similar to Mercury. When this vehicle comes back to earth it actually travels at a very high speed, much higher speed than is necessary to capture it in a low earth orbit. So we need retrorockets to slow it down.

It slows down enough so that it enters the atmosphere and then it can come in in the same manner as the Mercury, having a heat shield on it to protect it from burning up.

Mr. SISK. Mr. Chairman?

The CHAIRMAN. Mr. Sisk.

Mr. SISK. As I understand, the contract on the single chamber is $102 million. That is, of course, you are only asking for $30 million in 1960, and so on.

Mr. HYATT. Yes, sir.

Mr. SISK. In projecting your thinking, how much money actually are we talking about, looking to the time when, let's say, Nova would be ready to fire?

How many hundreds of millions of dollars do you assume we are talking about? Or do you have any concrete figures on that—Dr. Dryden or anyone?

Mr. HYATT. We don't have the concrete figures on that.

Dr. DRYDEN. We had some guess at it.

Mr. HYATT. We have some guess at it; yes.

Mr. SISK. I of course hesitate to ask you to guess. I am wondering if we aren't talking about somewhere in the neighborhood of possibly up toward a billion dollars?

Mr. HYATT. I wouldn't be a bit surprised.

Mr. SISK. We are talking about a lot of money. I am not opposing the program; I think it indicates good thinking. But certainly we are talking about a great deal of——

Dr. DRYDEN. This is over a period of about 6 to 8 years. So if you take a billion dollars, it means that this program would be carried on at a level of—divide this by six or eight. It of course would be a rising curve.

The CHAIRMAN. It would be about $100 million to $150 million a year, then.

Dr. DRYDEN. Yes, sir.

Dr. SILVERSTEIN. The longest leadtime item, Mr. Chairman, in the program is the engine. So we have started the engine first. Next year, in our 1960 budget, we also will have an item for a study of this vehicle system which will generate the numbers you have just asked—the additional costs and the weights of the items.

We will be in a position from then to move ahead in 1961 with some of the other parts of the booster. This is a general outline of the program.

Our 1960 funds do include monies to do a study on this vehicle.

Mr. SISK. Just to pursue a little further, that of course was one of the reasons for my question. I think this is wonderful foresight here to be projecting this program. But it is something, of course, that we must realize what we are launching when we authorize the expenditures even on this, as of course already the contract has been let. We are really committed now to going all out into this space field.

I am thinking now of peaceful uses of space separate and apart from any military program, because as I understand it you don't particularly anticipate any direct military application other than what actual conquest of space may contribute to military application.

Dr. DRYDEN. I think the military might take a different view. It is a question of what you think about the military uses of space stations, for example—which is one of the items.

Mr. SISK. I was modifying my statement by the fact that I was not precluding the fact that space as such may ultimately determine our—let's say—freedom and liberty because of the very things that may happen out there. But basically this part of the space program is separate and apart from the military program at the present time.

Dr. DRYDEN. I would say that the engine in itself is a common element. We are talking here about its applications to exploration of space. I think it is very important that you gentlemen should understand and the public should understand, that if you are talking about putting a man on the moon, this is what you are talking about.

The CHAIRMAN. Let's go a little further, Doctor. Suppose you had that vehicle and you decided to send one up every week. What would it cost to operate ——

Dr. DRYDEN. You won't be willing to send one a week, I don't think.

The CHAIRMAN. What will it cost to operate one of them if we send one up at one time?

Mr. HYATT. We estimate a figure of about ——

The CHAIRMAN. Just actual operating cost after it is all made and all set up, actual launching, putting it on the pad, filling it with fuel, tapping it off and watching it come back?

Mr. HYATT. I would say, just to make a rough guess, about $5 million just for that. That doesn't include the cost of the vehicle.

The CHAIRMAN. Nothing preliminary to putting it on the pad.

Mr. HYATT. That's right.

The CHAIRMAN. Five million dollars a shot?

Mr. HYATT. This is just for the fuel and various operations, but not any part of the vehicle.

Dr. DRYDEN. The big cost is the development cost. In other words, it is going to cost you maybe three-quarters of a billion dollars to develop this system. After you put that money into it, maybe it costs $20 million a shot?

Mr. HYATT. We estimate more than that—twice that.

Dr. DRYDEN. You won't be doing these one a week by a long shot.

The CHAIRMAN. Five million dollars a shot. Even at that minimum, that is a pretty good cost.

Dr. DRYDEN. Yes; I should say it is.

Mr. HYATT. Mr. Chairman, I would like to make clear that that $5 million does not include the cost of the vehicle.

The CHAIRMAN. I understood that. Just simply getting it from the time you put it on the launching pad, setting it up, filling it with fuel, and sending her off and getting her back.

Mr. SISK. I would just like to say that, based on what I have been able to gather from your comments—and I am not attempting to pin you down, but I am going to speculate, Mr. Chairman, that when we land our first man on the moon and bring him back, we will have invested about $2 billion in this program.

I hope I live to see the final figure on that. But I would say if we can do it for $2 billion, we probably would have accomplished something that certainly 20 years ago we would not have believed possible at any price.

Dr. DRYDEN. I know you have been in close contact with the missile program. You want to be clear as to space costs at the present time because the Atlas-Thor developments were written off and not chargeable to space. We are talking about vehicles more complicated than intercontinental guided missiles, and you aren't going to build them any cheaper. They are going to be more expensive.

When you talk about going into these space vehicles, you are talking about additional systems which get more complicated and more expensive than new intercontinental ballistic missile systems.

The CHAIRMAN. Dr. Dryden, if you do that, though, for instance build Nova, a great deal of that experience certainly and a great deal of your know-how and the actual cost can be assigned in the long run to other developments.

Dr. DRYDEN. Every vehicle before this you recall has been based on Atlas. So our basic boosters have their costs written off in the ballistic missiles. This is the first new engine we have talked about for space; a new vehicle for space.

The CHAIRMAN. If you started from scratch and had to build that without the experience you had from Atlas and these other——

Dr. DRYDEN. You couldn't do it.

The CHAIRMAN. You couldn't build it at any price.

Dr. DRYDEN. That is correct.

Mr. MCDONOUGH. Mr. Chairman, just to coordinate my thinking on this, were the pictures we saw on the screen the tests of this model you have on the table?

Mr. HYATT. No, sir. That was not this specific model, but in order to design and develop these engines, you build many test models. That was one of the test models.

Dr. DRYDEN. Thrust chamber plus a little bit of the skirt. That is why it looked so much smaller than this one.

Mr. MCDONOUGH. So once we have perfected a million-pound thrust, then the other five engines you have on the model here will not cost as much as the first one; isn't that true?

Mr. HYATT. That is right.

Dr. DRYDEN. Yes.

Mr. MCDONOUGH. So that your experience in research and development in the first engine is going to be one of your big costs, and that will reduce the cost on future engines. What experience have we got on the second- and third- and fourth-stage engines there? Are they going to be as costly as the development of the first?

Mr. HYATT. I wouldn't think so.

Dr. SILVERSTEIN. The second stage uses one of these engines, you see, and it is taken care of. The third stage involves the use of the special fuels. We are working, you know, with a lox hydrogen engine currently. We will discuss that with you a little later here in part of our presentation.

I think there is one point which should be brought out. We are talking about our future capability when we talk about this engine and talk about the Nova booster. We are talking about what we will have in this country 8 years from now and perhaps 8 to 10 years from now. I think it is essential that we realize the rapid rate at which progress is made in all of these fields. I know when I first entered the aircraft field, fighter airplanes weighed 1,600 pounds.

When they went to 2,000 pounds everybody was a little bit shocked. Now we talk about 100,000 pounds, and no one shivers.

I point out this has been in the period of my growth in the aircraft industry. What we need 8 to 10 years from now, I think, needs a lot of thought right now. Our development of this engine is based on many, many technical opinions.

We have rounded up three or four committees of the finest technical brains in the country who have reviewed the needs for this engine and unanimously they concurred in the necessity now for going ahead with this engine, attempting to project ahead what we might need.

It of course always comes down to a matter of judgment. Those who have watched the field believe it is the thing we need.

The CHAIRMAN. What kind of material do you use to construct that vehicle?

Mr. HYATT. I would like to answer that in closed session, since that particular information is classified.

The CHAIRMAN. Any further questions? Doctor, do you have a question?

Mr. HECHLER. Is the material in the heat shield classified? What do you use for that?

Mr. HYATT. I will have to defer that.

Dr. DRYDEN. There are two forms of heat shields under study. I think we will hear that in a presentation. One is a heat sink type made of beryllium. The other is an oblation type shield.

We are trying both types. In many respects the oblation type has advantages if it works. The advantage is very simple. The heat sink carries a lot of heat with it. We like the oblated type because the hot material flows away and doesn't remain around.

Remember, we have got a man in there.

Mr. KARTH. Mr. Chairman, what will be the greatest speed that this vehicle is expected to attain from here to the moon?

Mr. HYATT. The greatest speed to conduct this mission—all we need is a speed a little bit higher than the earth escape velocity.

Mr. KARTH. Is that the highest speed it will attain?

Mr. HYATT. Yes.

Mr. KARTH. That is what it takes to escape the earth's atmosphere. But it certainly attains a greater speed than that once it has escaped, doesn't it?

Mr. HYATT. No. Actually once it reaches its maximum escape speed, then it will begin to slow down.

Mr. MCDONOUGH. You just boost it away from that gravitational pull all the time?

Mr. HYATT. Yes, sir.

Mr. KARTH. I thought maybe the third or fourth stage or whatever it was would boost it well beyond the escape velocity. Some rockets are designed, are they not, that once they get into space, a further boost propels it to tremendous speeds beyond the escape velocity?

Dr. SILVERSTEIN. There may be missions we will use this on. For example, if we try to take a mission that is out of the ecliptic in which the earth and all the rest of the planets roll, we can find velocity requirements as high as, say, 50,000 feet a second or 52,000 feet a second in some of the missions.

So there can be missions that will require speeds higher than the escape velocity of 36,200 feet a second.

Mr. KARTH. What is the estimated round-trip time of this?

Mr. HYATT. The round-trip time need not be any longer than a week, depending on how much time one wants to spend on the moon.

Mr. KARTH. I am assuming there wouldn't be too much time spent there.

Dr. DRYDEN. Roughly one and a half to two days each way.

Mr. SISK. Mr. Chairman?

The CHAIRMAN. Mr. Sisk.

Mr. SISK. I have a little different series of questions I would like to ask of Dr. Silverstein if it is in order here. I suppose at a later

time someone will discuss the requests in this budget for research work, basic work, in possibly new types of engines.

The reason that I ask is the fact that, as I am sure you gentlemen are much more familiar with than I am—but some of the younger scientists indicate since the original engine was built—and frankly going back to some of the first ones out at Rocketdyne, they all looked about like that same engine, and they all have about the same principle and they all are predicated on about the same type of fuels and so on.

I know there is some concern among some of the scientists that we have kind of closed our minds or become a little inflexible, and that there are possibly breakthroughs in new types of engines.

I am thinking, for example—and I am sure you people are familiar—of a proposal put forth by a young scientist recently which he is working on. I believe possibly ARPA has some interest in it, a principle somewhat different entirely from this type of engine. I am interested in what NASA is doing and how much money there is in this budget and how much vision is being used looking to a new type of powerplant rather than just saying, "Well, this is it. In principle this is it, and we have just got to build larger and larger engines built on the same principle."

I would like to hear your comments on that and what NASA is doing, Dr. Silverstein, along that line.

Dr. SILVERSTEIN. The program we submit here has funds in it for development of the type you mentioned—that is, to advance the technology. We will discuss with you later some of the elements in the budget items there that have this character.

We are now moving ahead in several directions toward advanced technology. I will mention several. There are new fuels to worry about. One of them are the combinations of liquid oxygen and hydrogen. We are doing more than advanced research here; we are actually doing development in this area.

We think this is close enough to do development. We are, however, doing research with a fuel combination that goes beyond the hydrogen-oxygen, which is the use of fluorine as an oxidizer with hydrogen.

We have a research contract underway now with the Bell Aircraft Co. in which actual tests are in progress. This is an extension of work that was initiated by the Air Force, which we have taken over as part of our advanced development.

We are working in addition on larger engines using these advanced fuels. We are working on the storable propellants and high-energy storable propellants. We are doing some supportive work in the advanced solid rocket areas. We are working not only on the engines themselves, but also on components of systems relating to these chemical engines.

Beyond that, of course, we are working on advanced-type engines which I will take up next in my discussion here, and you will get some feeling for the engines we are moving ahead to.

Mr. SISK. Thank you, Mr. Chairman. I will probably have some further questions along this same line at that time.

The CHAIRMAN. Any further questions? If not, thank you very much, Mr. Hyattt.

At this time I will say this. It is 4 o'clock. Since it is Monday, I imagine the members have got some work in the office. If there is no objection, it would seem to be this would be an appropriate place to recess until tomorrow morning at 10 o'clock.

We are making very good progress in reference to handling the matter. As we go along, maybe our questions will build up, I am sure, and we will have more questions.

If there is no objection, then, we will recess until tomorrow morning ing at 10 o'clock.

(Whereupon, at 4:05 p.m., the committee recessed, to reconvene Tuesday morning, 10 a.m., April 21, 1959.)

1960 NASA AUTHORIZATION

HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
Washington, D.C., Tuesday, April 21, 1959.

The committee met, pursuant to recess, at 10 a.m., in room B-214, New House Office Building, Hon. Overton Brooks, chairman, presiding.

The CHAIRMAN. The committee will please come to order.

This morning we have, members of the committee, Mr. Addison M. Rothrock, Space Capabilities of Nuclear Rockets—Projects Rover and Snap.

Mr. Rothrock, what is your official position with the Department?

Mr. ROTHROCK. Scientist for propulsion in the Office of Program Planning and Evaluation.

The CHAIRMAN. You graduated from Pennsylvania State College. You came from Lewis Flight Propulsion Laboratory here.

All right, sir, do you have a statement prepared that you would like to give?

Mr. ROTHROCK. Yes, sir, I am going to work from charts as the previous witnesses have done.

The CHAIRMAN. Excuse me a moment, before we proceed. I have a letter here from Mr. Hechler saying that he has had to go home this morning on the 7 o'clock plane and will be gone several days and will miss these committee meetings.

All right.

STATEMENT OF ADDISON M. ROTHROCK

Mr. ROTHROCK. Actually I want to discuss two subjects this morning. First is the application of nuclear power to space propulsion, either through the use of what we will term "thermal rockets," such as in Project Rover, or what we term "electric rockets."

The second part of my discussion will be aimed toward the generation of electric power, per se, for use aboard a spacecraft; power to operate radios and to operate television. If we have people aboard, power to operate, say, even hotplates.

Going first to the propulsion system, at the end of yesterday's session Mr. Hyatt discussed with you gentlemen a flight to the moon and return in which, starting out with roughly a 5-million-pound gross weight, we showed a possible flight to the moon and return to earth with a 2,000-pound capsule containing a man, which we termed the payload.

What the propulsion system does in all these space flights is essentially to change the velocity of the vehicle. We very seldom talk

about the actual velocity at which the vehicle is traveling. We do talk about the changes in velocity.

For instance, to put a vehicle in orbit, we must give it a velocity of 17,000 miles per hour from the earth. To take a flight past the moon, such as was recently done, we must give the vehicle a velocity of 25,000 miles an hour. These are all positive. They are increasing velocities.

If we want to go to the moon and return, the propulsion system must supply a velocity change of roughly 45,000 miles an hour.

Of this 45,000, about 32,000 miles an hour is increasing velocity and 13,000 miles an hour is decreasing velocity.

The propulsion system does not care whether it is asked to increase or decrease velocity as was shown by the flight in which we ended up with our 2,000-pound capsule sent to the moon and returned to the earth's surface.

Now, if we want to fly a man to Mars and return to the earth's surface, the total velocity change is 75,000 miles an hour, of which roughly 48,000 is an increasing velocity and 27,000 is decreasing velocity.

If we want to make a flight to circumnavigate Mars and come back to Earth and do it in a relatively short period of time—9 months—our total velocity change will be of the order of 100,000 miles an hour.

Yesterday with chemical devices we saw that we can go up to this velocity change of 45,000 miles per hour. We need to obtain higher velocities. The total velocity change is very much dependent on the velocity of the propellant, of the jet that comes out the rear of the rocket. In fact, the velocity change of the vehicle is directly proportionate to this velocity, so we want this velocity to be high.

We must go to nuclear rockets to get this velocity higher than we can with chemical rockets. In the chemical rockets, we can get it up to the order of 9,000 to 10,000 miles an hour. This is about our limit, using such fuels as hydrogen and oxygen or fluorine, as was discussed yesterday.

There are certain other possibilities in what we call metastable chemical compounds. Although there is interest in them, we don't see as yet how we can solve the problems presented by their use.

So essentially we go to nuclear energy to get a means of increasing this propellent velocity.

When I talked to you gentlemen before, I told you this velocity was proportional—if it is done thermally—to the square root of the temperature to which we heat the gas divided by the molecular weight of the gas particles. In the chemical rocket this temperature is obviously limited to the temperature of combustion of fuel and oxidant. The molecular weight is limited to the molecular weight of our combustion gases.

If we use nuclear heat, we might remove this temperature limitation. We can't currently, but we can decrease the molecular weight of the propellent gas from a value about 11 to a value 2 and thereby increase the propellent velocity.

With a nuclear rocket we still need a propellant, but our energy source is now nuclear and we have a separate choice for propellant. We choose hydrogen because it is a light gas with a molecular weight of 2.

Before we go to the nuclear rocket I have put here the specific impulses that we can get with our different systems. Specific impulse and propellent velocity measure the same thing. They are two different ways of expressing the same factor. I can give the velocity in feet per second or miles per hour, or I can express the same thing as thrust produced per pound of propellant discharge per second (specific impulse).

If the specific impulse is 300 and I discharge 1,000 pounds of propellant per second, I get 300 times 1,000 or 300,000 pounds of thrust, which is roughly the thrust of the ICBM type of missile.

Mr. SISK. Mr. Chairman, would you say that again? I am trying to get this clear here.

Mr. ROTHROCK. If each pound discharged gives me 300 pounds of thrust, that is each pound discharged per second gives 300 pounds of thrust second, and I discharge 1,000 pounds a second, I then get 1,000 times 300, or 300,000 pounds of thrust.

I could have expressed the 300 pounds of thrust per pound of propellant per second as a velocity. It would have been around 6,600 miles an hour. Specific impulse is the more convenient term. I think velocity is a little easier to understand in the overall picture.

Chemically we have this specific impulse range, from the order of 200, say, to the order of 400 pounds of thrust per pound of propellant discharged per second. If we could use what I referred to as a metastable, this is the partially decomposed chemical compounds, I could get this result.

Work is going on in this field at the Bureau of Standards. As of now, we do not see how we will solve the problems of maintaining these unstable chemicals in a fuel or oxidant.

With the nuclear rockets, this is something we know we can do, we can get specific impulses of the order of two to three times that with the chemical propellants.

When I talked to you gentlemen before, I pointed out with the electric rockets we use an electric force to propel the mass outward and we remove temperature as a limitation. I have now gone to specific impulses of the order of 10,000 to 30,000.

This, of course, is good. It will give us a greater velocity increase to our vehicle for the same rate of propellant discharge. There are disadvantages to it. I will come to them later.

First, we will discuss the nuclear rocket, that is, the nuclear thermal rocket. Project Rover is a nuclear thermal rocket.

This rocket is shown diagrammatically in the sketch here. Again we have the conventional rocket. This is a single stage, and we have a chamber in which we heat the propellant. It this had been a chemical rocket we would have called this the combustion chamber. Now, instead of burning kerosene and oxygen we put a nuclear reactor in here. And as a nuclear reaction takes place, the reactor, of course, heats up. Then we force hydrogen (the propellant) by means of pumps or pressure from the tank here over the hot nuclear reactor. The hydrogen is heated and then expands and so increases its velocity as it comes out here.

So the difference between this and the chemical rocket is that the heat is obtained by a nuclear reaction rather than a chemical reaction.

Since the heat is obtained by a nuclear reaction, we have a wide choice of propellant. It doesn't have to be something that will burn. As I said before we use hydrogen because we want a light material.

The research that has to be conducted on the nuclear rocket is divided into two parts: First, on the reactor itself; second, on the system for adequately handling and delivering and discharging the hydrogen.

The Atomic Energy Commission is conducting research on the reactor itself, known as Project Kiwi.

The NASA is financing the research on the means of handling the propellant and bringing the complete unit together into a working propulsion system, that is into a working nuclear thermal rocket.

What can we do if we perfect this? As a single example, with a chemical rocket system with four stages—we discussed four stages yesterday—and a gross weight of a million pounds, we could put roughly 6,000 pounds in a flight to or beyond Mars.

If, instead of the two upper chemical stages, we put one nuclear rocket stage, we would increase that payload roughly fourfold, to about 25,000 pounds.

This again is why we want and need nuclear rockets. The chemical rockets that we discussed yesterday are largely in the development stage—we can go ahead and build hardware—nuclear rockets however are in the research stage. We are not in a position as of today to build a workable unit. Research must be conducted before we do this.

You notice I have a shield shown here. This is to shield the upper part from the nuclear radiations. The weight of the shield, of course, will depend on what we have up here, whether we have living matter, say people, up here. These things have to be decided, have to be worked on.

So we have seen with the nuclear rocket our objective is to get greater payloads in our space missions with a lower overall gross weight.

The CHAIRMAN. Mr. Rothrock, there is a question.

Mr. KARTH. How many times could you multiply the payload if you were using an electrical rocket rather than nuclear?

Mr. ROTHROCK. I will come to that on the next chart.

Before going to the electric rocket, let us remember that the specific impulse with the nuclear thermal rocket ran of the order of 1,000, and the velocity of discharge running of the order of 2,500 miles an hour. Our limitation is the temperature to which we can heat this reactor.

Without going into classified material, we know that to get material, solid materials, to withstand high temperatures of the order of 2,000° F. or higher is not easy. Research has to be conducted to learn how to operate this at higher temperatures and how to make a complete workable system.

Mr. SISK. Mr. Rothrock, before you leave that, just one question. As I understand, of course the Atomic Energy Commission is doing the research on the reactor. But so far as putting together the whole component, that is Project Rover; is that correct?

Mr. ROTHROCK. Project Rover originally was applied to the reactor itself. I would assume Project Rover does describe the complete project. I certainly think it is satisfactory to consider it in that manner.

Mr. SISK. Thank you, Mr. Chairman.

Mr. ROTHROCK. Now we go to the electric rocket. We showed on the first chart that we can get specific impulses here of the order of 10,000 pounds of thrust for each pound of propellant discharge per second. It is discharged in this case in this direction with velocities coming out here of the order of 200,000 to 300,000 miles an hour.

We shouldn't concern ourselves with the size of these figures. All figures are relative. We think these are high now because we haven't worked with these velocities before. As we get accustomed to them we won't think of them as being high.

Since I am going to use an electric force now to cause my propellant to accelerate, I must have electricity. That means that with the electric rocket, and this is often termed an ion jet or a plasma jet, I must have an electrical generating system. In this case we use a nuclear reactor similar to what we are using in our generation of power elsewhere. By means of what we call a working fluid—it could be one of various liquids—which is heated in the reactor we drive a turbine. The fluid then goes through its complete cycle as shown. The turbine drives a generator. The generator produces electricity.

Now we come to the difficulty in this device, that is the power we have to put in this jet. So far I have talked about velocities. I have not talked about power. There must be power in this jet.

Whereas with a chemical rocket the power in the jet is of the order of 9 to 10 horsepower per pound of thrust produced and in the nuclear thermal rocket 30 horsepower per pound of thrust produced, in the nuclear electric we talk about 200 to 500 horsepower for each pound of thrust produced.

Electrical generating systems are not light. If we have a weight of 10 pounds per horsepower of electricity produced, we are doing quite well. If we have to have 300 horsepower for each pound of thrust produced and 10 pounds for each horsepower produced here, the powerplant will then weigh 3,000 pounds per pound of thrust produced.

Our chemical rocket system will weigh in the order of three one-hundredths of a pound per pound of thrust produced. So we have to offset the advantage of a high velocity with a small amount of propellant with the weight of the electrical generating system.

Now, under what conditions will we use this system? The position between nuclear energy used with an ion or a plasma jet and a nuclear energy used with a thermal rocket is not as yet clear. We do know that when we get to these more difficult missions such as to Mars and return, we will probably want one or the other. We may use them both.

Research has to be conducted on both of them to find out what the most advantageous result is. Research is going on in the means of handling this propellant so we can accelerate it electrically. The propellant may be cesium, a metal which is liquid under fairly decent conditions.

These I have shown are two of our more advanced kinds of propulsion systems. I could mention others. I am not going into them now. We could have a device that would eject energy instead of mass out here.

We might conceive a nuclear reaction in which the products of the reaction themselves were ejected as a jet. These are things on which

research, largely with pencil and paper, is currently being conducted. In regard to amounts of money, in the nuclear——

The CHAIRMAN. Let me ask you this: Do all of these experiments embody the same principle of propulsion—that is, by jet propulsion?

Mr. ROTHROCK. That is correct.

The CHAIRMAN. There is no substitute for that; is there?

Mr. ROTHROCK. Basically there is only one method of propelling something in space, and that is to either eject something from it or throw something at it and reflect it from it. We could have a large solar sail, with the energy of the sun reflected from it and get propulsion in that way.

But in general, to propel a device in space, to change its velocity, we must eject, that is, accelerate from the device, mass or energy. This is of course mass. If I talked about photons, then I would be talking about energy. The basic principles are well understood and have been understood for many years.

The amount of money for the nuclear thermal rocket that we are requesting for fiscal 1960 is $8 million. The amount of money we are requesting for research on the electric type of device is $3 million.

I now come to the second portion of my presentation, which is the generation of electricity aboard a space device. Electricity is a flow of electrons. Consequently to generate electricity we want a device that causes electrons to flow through an electric conductor and through a——

The CHAIRMAN. May I ask you another question in reference to the cost. Yours is the only agency which has a project of those two kinds—one requiring $8 million, the other $3 million. Is there any other agency of Government that has anything like that?

Mr. ROTHROCK. Project Rover, of course, is being done jointly by the AEC and the NASA. I am giving you only the funds that are being requested for the NASA portion of the nuclear thermal rocket.

The CHAIRMAN. Is the nuclear thermal rocket being handled by you or by the AEC?

Mr. ROTHROCK. Jointly by the AEC and NASA.

The CHAIRMAN. What about the electric?

Mr. ROTHROCK. On the electrical, the Department of Defense has certain contracts in this field also. I do not have the sum of them at hand.

The CHAIRMAN. Does the $3 million cover the Defense Department?

Mr. ROTHROCK. No; it covers only ours.

The CHAIRMAN. Does the $8 million cover the AEC?

Mr. ROTHROCK. No; the $8 million doesn't cover the AEC.

The CHAIRMAN. Just your part. Do you know how much they are putting in?

Mr. ROTHROCK. I do not have that figure currently.

The conventional method of generating electricity is of course an electric generator with which you are all familiar. We can drive an electric generator in space by means of, say, a nuclear reactor which heats a fluid which goes through a turbine and drives the turbine, which in turn drives a generator. But this fluid must also go through a radiator to give off the heat we didn't use in the turbine and be pumped back to the heater.

This boiler can be heated by chemical energy or by nuclear energy. Nuclear energy either coming from a reactor or the nuclear energy from the sun, in which we would collect it upon a large reflector. We wouldn't use chemical energy here because the energy output per pound of material consumed is too high. I think we are fairly certain of that.

We will use nuclear energy, either directly or solarly.

This is the system about which we know much, on which much work has been done and much work will continue. Of course in the nuclear electric rocket we had to have essentially this part of it anyway to generate our electricity.

There are other means of generating electricity on which we are working. One is what we call a thermopile. If we have two dissimilar metals, A and B, and we keep them in contact here hot and in contact here cold, electrons will flow and we will have electricity, which can go through an electrical load.

The amount of electricity produced depends upon the materials used and the temperature difference. Whereas the efficiency or the ratio of energy consumed to electricity produced will run 25 to 30 percent in the previous system, on this it is currently running of the order of 6 percent. This means a larger energy source and a larger radiator to get rid of excess heat.

The nice part of it is there are no moving parts in this system except for such circulation of fluids as is required.

Project Snap is this type of system. As currently devised, these weigh about a pound per watt. That would be 1,000 pounds per kilowatt, or a bit more than that in pounds per horsepower. So the device is heavy if we have to produce much power.

We cannot consider it as yet to produce the electricity required for propulsion, but we do consider it to produce the electricity that we will want aboard our space craft.

The system is subject to running for long periods of time because the amount of energy used per unit of electricity or the rate of nuclear material consumed per unit of electricity produced is small.

So when we are talking about devices which may run, say, many months, we will talk about this kind of a system. Research is actively being conducted on this.

Again we call this a thermopile. Another means of——

The CHAIRMAN. How much money are you putting into that?

Mr. ROTHROCK. We are putting $3 million into this group that I am now showing.

The CHAIRMAN. The whole group?

Mr. ROTHROCK. $3 million total.

The CHAIRMAN. Could you give us the figures, or obtain for us the figures from DOD on that project?

Mr. ROTHROCK. We will.

The CHAIRMAN. And the figures from AEC on the other project?

Mr. ROTHROCK. Yes, we will try to do so.

(The information is as follows:)

For electric propulsion systems, Department of Defense has allocated $12.25 million (this includes power generation as well as electric propulsion).

The Atomic Energy Commission has allocated for Snap program $12.1 million, and for the Rover program, $19.8 million.

Mr. RIEHLMAN. Mr. Chairman, are these figures broken down in your estimate of appropriations in this book anywhere?

Mr. ROTHROCK. Yes, sir.

Mr. RIEHLMAN. I wonder, can you tell us where they are? I would like to be following them if I can, a little better.

Mr. ROTHROCK. Page 268, I think it starts.

Mr. RIEHLMAN. Is it under "Nuclear rocket engines"?

The CHAIRMAN. Are books available?

Mr. DUCANDER. Of course we hadn't distributed those. We are going through this item by item when we start reading the amendments.

The CHAIRMAN. Some of us are going to follow the books. We either all ought to follow them or none at all.

Mr. ROTHROCK. I am now on page 274.

Mr. RIEHLMAN. The only reason I speak about it, Mr. Chairman, it is much easier to follow it to some degree right now when we are going through it if we can.

The CHAIRMAN. I think what Mr. Ducander has in mind, until we get down to particular details there, it would be better to get the general impression.

Mr. DUCANDER. However, we have the books here and we can put them out.

Mr. RIEHLMAN. I had mine. It was brought to the committee.

Mr. ROTHROCK. Page 274.

Another means of producing electric power is to heat a given metal and have it face another metal at a colder, lower temperature. Electrons flow from the hot plate to the low plate and through our electric load and so produce electricity.

This is used in our radio tubes, in our TV tubes.

The source of energy to heat this hot plate will be nuclear, either nuclear, from a nuclear reactor, or from radioactive decay which we might call a minor nuclear reaction, or, say, from the sun.

But again research effort is the same as previously—to learn how to make this system light and reliable, to get appreciably lower weights than the pounds-per-kilowatt. The kind of efficiencies we are talking about here, I believe, are the same as those we discussed previously.

The type of system that will prove most efficient, most usable, we do not know at the present time. I have talked about two methods of producing electricity by means of heat directly without going through the turbine cycle. I can also produce electricity by impinging light on certain materials, the second material here, and this causes electrons to flow through here to here and returning by means of the wire to our electric load and again we have electricity. This is listed as solar. Probably we would use the light energy from the sun.

Remember that heat and light are basically the same thing as far as we are considering them here. It is radiant energy.

The photoelectric cell is a fairly usable device. It is used in stores or stations to cause doors to open automatically when you go through them. It is used in the light meters of your camera and so forth. In that case weight is not important. Weight is important here. So our objective here again is to get this thing light and get it reliable.

So these are the various methods on which we will conduct research to get the means to produce electricity in our space vehicle.

I have not discussed the chemical means. They are also used when the periods of flight are shorter. Vanguard used a solar battery. Our other devices have currently used chemical batteries. But remember, the lifetime is short. When we are talking in lifes up to several years, we are then more interested in devices of this sort.

That completes my presentation, Mr. Chairman.

The CHAIRMAN. Thank you very much, Mr. Rothrock. The next witness we have here is Dr. Homer E. Newell, Jr., who is specialist in space science. Do you have a prepared statement?

STATEMENT OF DR. HOMER E. NEWELL, JR.

Dr. NEWELL. I have charts, just as Mr. Rothrock, from which I would like to talk, Mr. Chairman.

Mr. Chairman, members of the Committee: Space sciences form an important part of the NASA program in space activities.

Dr. SILVERSTEIN. I might point out that page 232 in the books is where he will start and go through to 244.

Dr. NEWELL. Under the heading of Space Sciences we include scientific investigations in space by means of sounding rockets—that is, vertically launched rockets—space probes, and artificial satellites.

Research in this area is necessary to extend the frontiers of our knowledge. It is basic research about which we are talking. It is research of this kind over the past many decades which has laid the groundwork for practical applications such as weather satellites about which you will hear later, and communications satellites, about which you will also hear.

The research in our program at the present time is essential to lay the groundwork for future applications—10, 15, 20 years from now. The space sciences area is very broad, so for convenience we have divided it into a number of different subareas. Atmospheres—and the plural is intentional here—ionospheres—and again the plural is intentional, because in both cases we will be interested not only in the earth's atmosphere and the earth's ionosphere, but those of the planets and of the sun—energetic particles—electricity, magnetism, and gravity—and astronomy.

In the next chart we pick up the study of atmospheres, illustrating it by a schematic diagram of the earth's atmosphere. Notice the scale here. We run up to 50 or 60 miles in this diagram, although the earth's atmosphere extends out for many hundreds of miles.

Notice also that we have included the sun here because the sun is the primary source of energy driving our atmosphere, causing the activity that goes on in it, providing the energy that causes the weather with which we are familiar.

In the lower part of the atmosphere is the region with which we are familiar, in which we live, in which we have our cyclones and anticyclones, rain, snow, hail, and so on.

The upper part of the atmosphere also has its own weather, but this weather is not based on water vapor, as is the weather in the lower part. It is based on the mixing, diffusion, winds, and chemical

changes—for example, of oxygen into ozone, and at higher altitudes, of oxygen into atomic form.

During the past 10 years or so, including the International Geophysical Year, we have learned quite a bit about the upper atmosphere. We have learned enough to know that it is quite variable and that there appear to be connections with the lower atmosphere, with weather. So one of our important practical objectives in studying the upper atmosphere will be to pin down what that connection is with our weather in the hope that in the future predictions may be improved and perhaps we may someday learn how to control certain aspects of the weather.

The objectives of the immediate program are illustrated in the scientific experiments that we wish to conduct in the next 2 years in atmospheres research. I should point out where we list here one space probe, three satellites and so on, we are actually referring to experiments.

This is an important point to note because if you try to add up the numbers of space probes and satellites here and those on the next chart of this type and those of the following chart, you will get far more space probes and satellites than we actually have in our program.

The point is that a given satellite is often devoted to many different experiments. I will illustrate this later in the case of a particular satellite.

One of our space probe experiments will be devoted to measuring the pressure, density, temperature, and composition of the atmosphere of Venus or Mars. In this we are looking out into space to the planets. We plan to use the techniques that we have been developing and are now using in the study of the earth's atmosphere.

We wish also to use one space probe, and in our program we are now preparing for it, to measure the density and composition of interplanetary space and the moon's atmosphere. We might think of this interplanetary space as the sun's atmosphere.

Prof. Sidney Chapman, for example, thinks that the sun's atmosphere extends not only to the distance of the earth, but far beyond, and at the distance of the earth has a temperature of about a quarter of a million degrees. If this is true, this means then that our earth is moving through a gas of a quarter of a million degrees temperature.

We have three satellites in our program to continue our observations on the pressure, density, temperature, and composition of our own atmosphere above 100 miles altitude, to pin down variations with geographic position, with time of day, and with season, and the variations with such longer periods as the sun spot cycle.

In the program are also included 40 sounding rocket experiments to measure the same quantities, but from 50 to 100 miles. This is a particularly important region because it is the region in which the lower part of the ionosphere lies and we will consider that a little later.

Similarly 40 sounding rockets are to be devoted in the next 2 years, to make a worldwide survey of the same quantities up to 50 miles altitude. This is of particular importance practically because it is in

this region that we expect to find clues to what causes the weather, or triggers certain aspects of the weather, and so on. The Weather Bureau is particularly interested in this part of the program and is joining us in this work.

In the next chart we moved on to the study of ionospheres. Now by ionosphere we mean that part of an atmosphere that is charged in which some of the particles have either lost electrons and therefore have become positive, or have picked up electrons and therefore have become negative in electrical charge.

The ionosphere regions also include large numbers of free electrons themselves. The complication of this subject can be seen from this chart. Note the daytime and nighttime features are different.

In the daytime we have several different layers divided into sublayers, whereas at nighttime we are left with only two layers in the ionosphere. Note that the scale on this chart is different from that on the previous one. We are looking out several hundreds of miles in this.

The sun again is the primary source of energy causing the ionosphere. Ionosphere is also affected by charged particles, presumably from the sun, and is related to the northern and southern lights, the aurora. The ionosphere is further complicated by the presence of the earth's magnetic field, which is shown schematically here. These lines indicate the magnetic force lines of the earth's field.

The ionosphere is of practical importance to us because of its effect on radio waves. Radio waves in the short wave region below 15 megacycles are reflected from the ionosphere at different heights, depending on their wavelengths. Thus one can, transmitting a radio wave, cause it to be bounced from the ionosphere back to earth, back to the ionosphere, back to the earth, a number of times and in that way send messages, send radio waves, beyond the horizon.

Without the ionosphere, it would not be possible to send radio communications around the world. During the past 10 years, including the International Geophysical Year, a fairly complete picture of the ionosphere has developed up to, say, the E region here at 60 miles. A somewhat less complete picture from the E region up to the F region here at 180 miles or so, and only brief glimpses have been obtained above the F region.

The principal objective in our immediate program is to pin down many of the details in the upper portion of the ionosphere. From the practical point of view, this is extremely important because it is the upper portion of the ionosphere that is of greatest use in radio communications.

On our 2-year schedule we have seven sounding rocket experiments to study the charge density in the ionosphere, how it varies with time and with altitude, to study the propagation of very low frequency radio waves—the frequencies that are used by the Navy, for example, in its worldwide communications net—and to study the effect of the ionosphere on rocket vehicles.

This is, of course, of practical importance because when a vehicle goes through a charged medium it picks up a charge. This may interfere with or modify the radio communications to the vehicle for instructions to the vehicle, or from the vehicle to find out what it is doing.

We have five earth satellite experiments for the same sort of measurements at higher altitude and over long periods of time. One space probe is being instrumented to measure the ionospheric structure out to as far as we can send the space probe. The principal question here is how far does our ionosphere go, how intense is it above the F region maximum, how is it related with the Van Allen radiation belt which was discovered during the IGY?

In the field of energetic particles we have cosmic rays, the Van Allen radiation belt, and the particles that cause the northern and southern lights. The cosmic rays are of particular importance to the scientist because they include particles of much higher energy than any that we can create in the laboratory. Some of the cosmic rays are as much as a billion times more energetic than any that we can create in accelerators like those at the Lawrence Radiation Laboratory, or at Brookhaven.

The cosmic rays are of practical importance because of the potential hazard to any animals or crews that we may send out into space in observing stations, or experimental satellites.

The Van Allen radiation belt is of particular importance because of the effect that it may have on radio communications, the possibility of using it to influence radio communications. At the present time the Van Allen radiation belt has been studied in a few traverses. It is important to pin down fully its total spatial extent, to pin down its relation to the sun, to cosmic rays, its variation with time, and its effect on vehicles that move through the radiation belt.

It is believed that the particles that cause the northern lights and the southern lights, the aurora, are actually particles trapped in the outermost zone of the Van Allen radiation belt. These are of practical importance because large auroral displays almost always are accompanied with disturbances of radio communications. In order to learn how to do something about this, we must first learn what the whole story is.

The program in this area is illustrated in the following chart. During the next year and a half we are preparing to perform experiments on the cosmic ray intensity itself, which is a fundamental scientific research experiment, with one satellite and two deep space probes. We want to measure the fluctuations in cosmic ray intensity in one satellite to try to pin down their origin.

If we can correlate these fluctuations with solar activity, we may get the data we need to assure ourselves that they come from the sun, or at least that a part of them come from the sun.

We also wish to identify completely these particles, to determine their energies and to find out how many there are at different energy levels, and to determine what they are. To say we want to determine their charge spectrum is another way of saying we want to find out whether they are hydrogen, helium, iron, or something in between. One probe, plus two rockets for this are in our program.

We wish to study further the radiation belt, its spatial extent, its composition, its variations with solar activity. Two satellites plus four rockets are being instrumented for this purpose.

Finally, we wish to study the auroral particles. For this, six small rockets are being instrumented to be launched in the Northern Hemi-

sphere, probably at Fort Churchill in Canada, where a large part of our International Geophysical Year rocket program was carried out.

Moving on to magnetism, electricity, and gravity, we come to some of the most fundamental of the researches that we can carry on. Shown here are the magnetic field lines for the earth in the form in which they would exist if there were no disturbing factors entering in from outer space. As you see, the field lines have very much the shape of the pictures you have seen of the Van Allen radiation belt. It is, in fact, between these field lines that charged particles that come in from the sun or are created in the earth's atmosphere from cosmic rays get trapped to form the Van Allen radiation belt.

It is in fact between these field lines that the electrons created in the Argus experiment were trapped to form a layer out in this vicinity.

We wish to determine how much disturbance to the earth's magnetic field incoming particle streams from the sun causes, because when this magnetic field is disturbed, compressed for example by a charged cloud sweeping in here, at the surface of the earth we experience what is called a magnetic storm and radio communications blackout.

In fact, if the storm is too severe and is associated with intense auroral displays, sometimes telephone lines and wire lines, are blacked out and become useless, particularly in the northern regions in Canada, for example.

The earth's electrical field we know to correspond to about 290,000 volts between the ground and the ionosphere, but we know virtually nothing about it above the ionosphere. This is something that we must study because the electric field must somehow be associated with the aurora itself and must have some effect on the charging of space vehicles and satellites launched into or through this region.

When we come to the study of gravity, we come to a subject which has long been under observation. People have long known about gravity and about its strength, but do not yet know what it is, or what causes it. Here we have perhaps the most fundamental subject of our space science program.

If we are ever going to develop any antigravity applications, which is a subject of considerable interest, we are going to have to first find out what gravity really is.

We have an opportunity at the present time to test one aspect of gravity, namely, the general theory of relativity. This can be done by sending a clock, a very accurate clock, one that can keep time, to 1 part in 100 billion, up in a satellite at, say 4,000 miles altitude, and comparing its running with a clock, a similar one, on the ground. According to the general theory of relativity the one in the weaker gravitational field—the one in orbit—should run more rapidly than the one on the ground. If this turns out to be true, this will provide us with our first controlled check on the general theory of relativity. In the past our checks have had to be made at the pleasure of mother nature. We have had to simply observe what she has permitted us to. This will be a controlled check.

Our program in this area is shown in the next two charts. For the next 18 months in magnetic fields and electric fields we plan two satellites to study the magnetic storm currents in the ionosphere and beyond, and to study current flows in the Van Allen radiation belt, because

these current flows are associated with the magnetic storms and radio blackouts at the surface of the earth, which I mentioned earlier.

One satellite will attempt to plot out the earth's field in detail, to locate disturbance sources and where they enter the earth's magnetic field, and to study the propagation of magnetic waves through the Van Allen radiation belt region.

One space probe will measure the moon's field, and the magnetic field between the earth and moon, and the earth's own far field.

Thirty sounding rockets are being instrumented to measure ionospheric currents below the region where the satellites will measure, and to provide tests of instrumentation that will later be used in satellites and space probes, in particular, instruments that will be used to study the magnetic fields of interplanetary space out to Venus and Mars.

In addition, we have some magnetic field experiments that are going to be carried on in space probes in this interval of time. We hope in these space probes to get out to the distance of Venus. If we get close to Venus we may be able to measure the field of Venus, but actually our hopes for that are not too high in these early experimental firings.

Again we will measure the interplanetary fields on the way and distortions of the earth's field.

In the gravitational field program are included geodetic measurements—that is, continuing study of the size and shape of the earth. As you are aware, the IGY program, based on observing IGY satellites and in particular the first Vanguard satellite, has shown that the bulging of the earth is slightly different from what was estimated from measurements made on the surface of the earth, and has also shown that the earth is slightly pear-shaped, with the peak of the pear at the northern pole and the flat part at the southern pole.

This of course is important to the man who makes maps and who wants to study the inner structure of the earth. One satellite will be devoted specifically to this. One satellite will be devoted to the test of the general theory of relativity, which I mentioned earlier.

Next we come to the field of astronomy. Astronomy has always been hindered by the fact that the observer at the surface of the earth is at tremendous distances from his objects of study, from the galaxy and from the intergalactic medium and galaxies outside of our own. Also, from the fact that the atmosphere lies between him and his objects of study.

This means that he has had to make his observations in the visible wavelengths and more recently in some of the radio wavelengths. This means that he has not been able to observe in the X-rays, the gamma rays, the ultraviolet rays, which probably can tell him much more about what is going on out there than what he sees in the visible.

With artificial satellites he can now look forward to making his observations from above the atmosphere over long periods of time. Eventually he may think of setting up an observatory on the moon, which would be even better.

Also, with space probes he may now think of sending out equipment to the moon itself and to the planets themselves for direct exploration.

In the immediate astronomy program some 30 to 35 sounding rockets are being instrumented for observations of all these things out in space.

In addition, there are three space probes experiments which are being prepared and six satellite experiments over the next 2-year period.

Now I have described a fundamental research program, a basic research program. The question often arises, and should arise: Why should we carry on such fundamental researches? What good do we get out of them from a practical point of view?

I point again to the fact that from this basic research we get the material out of which practical applications arise. We know that these will come. We know that some of them will pay for the effort and the expense over and over again.

But we don't have to rest content with just these general remarks. We can point out specific applications that we know are going to come. For example, in the atmospheres research I pointed to the applications to weather. The more we know about the weather, the better our predictions can be with longer-range predictions in time, and perhaps someday we may be able to control certain aspects of weather.

We also have had from the IGY work and previous work, an application from atmospheres research in the formulation of the engineering atmosphere that is now used by engineers in their design work on aircraft and high-flying vehicles.

We can expect that the continuing research in atmospheres will continue to improve this engineering standard atmosphere and extend it to higher altitudes to be used in the even higher-flying vehicles.

In the case of ionosphere research, the communications problem, of course, is intimately related here. I have mentioned some of the importances. I might point out that during the IGY, the ionospheres research indicated that during a polar blackout when radio communications in the northern regions were simply wiped out, the lowest region of the ionosphere was very greatly intensified. It is important to us, then, to be able to predict when this is going to happen and to be able to predict what frequencies might be used to get around this problem.

There is also the possibility that by creating an artificial ionosphere chemically, for example, by emitting chemicals from the rocket into the ionosphere, we may be able to create reflecting clouds that we can use for a short period of time for communications, set up a temporary communications link.

It is background information on the ionosphere that will permit us to do this sort of thing.

In the energetic particles area, from a practical point of view we have mentioned the potential hazard of cosmic rays. In order to evaluate this hazard, we must know thoroughly what the cosmic rays are, how they behave, how they vary with time.

We have talked about the Van Allen radiation belt. I might point to a practical matter here. Mr. Rothrock in his previous talk mentioned the use of ion rockets, which have low thrust, for moving from a point in orbit about the earth on out into the solar system.

Because these rockets will have such low thrust, the drag on these rockets is an importat factor to know.

The Vanguard I satellite has already indicated that when it moves through the Van Allen radiation belt it acquires a charge corresponding to a potential of some thousands of volts. This charge increases the drag on the satellite by a factor of between 10 and 100. This is going to be important to know in connection with low-thrust rockets like ion rockets.

In the case of magnetic fields, the fact that the magnetic field provides a natural trap for charged particles means that we may be able to exploit this region in the communications area by injecting, as in the Argus experiment, electrical particles into this region to provide reflectors.

Again the gravity question. I mentioned that this was very fundamental. You may ask what is the practical value of such very fundamental researches? What is the immediate benefit?

I should point out that in the relativity area, which is one of the subjects in the gravity area, the equivalence of mass and energy was derived. It is the equivalence of mass and energy that led to the nuclear bombs and nuclear power that we are making so much use of today.

It is this sort of thing that we look to when we undertake such fundamental researches.

Turning to the area of astronomy, we recall that astronomy has down through the centuries continuously given stimulation to the other disciplines, to physics and chemistry. For example, out of astronomy grew the foundation of mechanics which is the basis for our modern engineering, civil engineering and mechanical engineering.

We may look forward in the future in astronomy, for example, in our study of the sun, to learning about our primary source of energy. The earth, every minute intercepts a billion, billion calories. That is a tremendous amount of energy, and it is this energy, of course, which goes into driving our atmosphere and weather.

It is this energy that goes into creating the ionosphere and the aurora, which is then important again to our weather studies and radio communications.

Now the moneys being requested for research in these various areas in space sciences will go largely into the supporting research and development that provides for the design of experiments, for the construction of payload packages, and for the collection and reduction and interpretation of data. As an example of such a payload package, we have what has been referred to as the heavy IGY satellite. It is now in preparation and should be ready for launching in the near future.

It is being worked on by the Army Ballistic Missile Agency and will be launched with a Juno II rocket.

Note the number of experiments that are brought together into one payload package. A cosmic ray experiment, Dr. Van Allen of the State University of Iowa, is working on that. Another cosmic ray experiment to identify the heavier particles in the cosmic radiation—Dr. Groetzinger was working on this until he recently passed away.

A solar radiation detector being worked on by Herbert Friedman of the Naval Research Laboratory. This is to observe the radiation given out by hydrogen in the sun.

Note here these little—we call them ping-pong balls. These are radiation detectors to determine the balance of radiation in the earth's atmosphere, the difference between the input of the sun's radiation and that that is reflected or given out by the earth. This is being worked on by Dr. Suomi of the University of Wisconsin. Here is a solar X-ray detector also being worked on by Dr. Friedman.

In addition to the experiments in here, one must have the power supplies that provide the energy of the equipment they need to run. Here are solar cells. You see these little windows here. Here is a package which contains the electronics. Here is a 20 megacycle antenna. This is for telemetering. Here is a 108 megacycle antenna. This is for radio tracking. There is a separation device which will separate this satellite from the fourth stage of the vehicle.

All of these things must be put together so that they will fit the vehicle, so that the equipment will still operate after having gone through the rigors of launching. The whole thing must be tested severely in the laboratory before it is committed to flight.

It is this sort of thing to which the moneys we are requesting must go.

In the next chart we can tie together the material presented earlier, giving you the number of rockets, satellites, and space probes planned for calendar year 1959 and calendar year 1960. In the sounding rockets area, using rockets such as Aerobee, Nike-Asp, Aerobee-Hi, Spaerobee, Jason, 45 to 50 in calendar year 1959, and 90 to 100 in calendar year 1960.

For satellites we will use Vanguards, Juno II's, Thor-Ables and the Delta rocket—Thor-Delta is the Delta rocket that Dr. Silverstein described yesterday. Eight of these are scheduled in 1959, six in 1960.

And space probes—again the Thor-Able, the Delta, Atlas-Able, and the Vega. Two in 1959 and four in 1960.

Thank you.

Mr. SISK. Mr. Chairman.

The CHAIRMAN. Mr. Sisk.

Mr. SISK. I wonder if Dr. Newell would comment on your cooperative program with Canada with reference to the ionosphere experiments? I noticed a press release just came out where you reach some sore of agreement apparently with the Navy where NASA furnishes the vehicles and Canada furnishes certain instrumentation. Would you make a comment on that?

Dr. NEWELL. Yes, I would be glad to. One of the most powerful ways of studying the earth's ionosphere has been to send radio waves up to the ionosphere which are then reflected back. By varying the frequency of these radio waves one gets information about the ionization at the different heights.

In order to exploit this technique from outside, it is planned to fly in a satellite the same sort of radio equipment which will send signals down, have them reflected back to the satellite and then the data that they obtain, analyzed in the satellite, will be sent back to the ground by a telemetering link.

The Canadians are particularly interested in this sort of an experiment because of the fact that a large part of their country lies under the auroral zone where the ionosphere has sometimes a very adverse effect on radio communications. They therefore offered to provide the equipment for the satellite, and equipment in ground stations to observe the satellite so as to make these measurements in the auroral regions.

The NASA and the Canadians are joining together to perform this experiment. We will provide ground stations in other regions than in the auroral zone, but the Canadians will provide those in the auroral zone.

Mr. SISK. Actually the two countries will be sharing the expense, then, to some extent?

Dr. NEWELL. Yes.

Mr. SISK. They will be contributing as well as the United States?

Dr. NEWELL. Yes, that is correct.

The CHAIRMAN. We will provide the vehicles?

Dr. NEWELL. We will provide the vehicles.

Mr. QUIGLEY. Mr. Chairman, may I ask one question?

The CHAIRMAN. Mr. Quigley.

Mr. QUIGLEY. Doctor, in the launchings you have listed there, are they cumulative or will it be possible to double in brass and use some of the launching for more than one purpose?

Dr. NEWELL. For example, any one of these launchings probably carries several different experiments in several different areas.

Mr. QUIGLEY. So the total launchings you listed, it will not take a separate launching for each item, each purpose?

Dr. NEWELL. That is correct. That is why we have, for example, only eight satellites during this period, whereas we have probably about 20 different experiments going into the satellites.

The CHAIRMAN. Mr. Osmers.

Mr. OSMERS. Mr. Chairman, my question is along the same lines as the gentleman from Pennsylvania. I am very glad that Dr. Newell has prepared this chart so that we can get some sort of a summary of the rockets, satellites, and probes that they have planned.

Dr. Newell, does this chart also include anything that the Department of Defense might do in this particular field? Is this the same program or do they have a separate program? I am not referring now to military application, but to scientific applications.

Dr. NEWELL. In general the scientific research comes under NASA. Some of the research included in this program will be done by agencies in the Department of Defense. For example, Dr. Friedman's group at NRL is working with us on some of the astronomy experiments. The Department of Defense, as I understand it, also has basic research experiments of its own. The Discoverer series, for example, includes those.

Mr. OSMERS. In the scientific program which the Department of Defense may have—we know they do have—does NASA participate actively in those experiments? Let us take the Discoverer program.

Dr. NEWELL. We are at the present time discussing this very subject with the Department of Defense. We had a meeting on it a couple of weeks ago. We have another one scheduled for next week to see

how we can jointly work out our mutual problems, participate in each other's programs.

Mr. OSMERS. In other words, the very fact that such a meeting is planned would indicate that there is probably a great deal to be done and to be desired in that particular field of cooperation.

Dr. NEWELL. It is a big field and a difficult field, which I think a lot of attention must be given to. We plan to do it. We have only just begun, so there is a lot yet to be done.

Mr. OSMERS. Do you feel, Dr. Newell—I am asking you the question as a scientist—do you feel that we have the strongest possible liaison and cooperation between NASA and the Department of Defense in the scientific program.

Dr. NEWELL. I would say we have the intention to build up that, but we don't have it as yet. We simply haven't had time to establish it.

Mr. OSMERS. Would you be able to give the committee any information, Dr. Newell, on the extent to which private—that is, nongovernmental research organizations—will participate in this program?

Dr. NEWELL. Our plan is to have the inhouse activity—the NASA part of the activity—in this space science work be about 20 percent of the total program. The remaining 80 percent we expect to be carried on by universities, private research organizations, other Government agencies, and industry.

Mr. OSMERS. So that will be generally—to use the term rather loosely—that will be under contract to private agencies and other governmental agencies.

Dr. NEWELL. Yes.

Mr. OSMERS. Would that type of expenditure—the expenditure of other Government agencies—go with, let us say, the Department of Defense.

Dr. NEWELL. Some of it. For example, some of the work that Dr. Friedman at NRL is doing will be paid for by us.

Mr. OSMERS. Would it be desirable from your standpoint—and this question might be beyond what you are to respond to, Dr. Newell—would it be desirable from the Nation's standpoint to take scientific research and experimentation of the type we are discussing this morning, remove that from the Department of Defense and centralize that under NASA.

Dr. NEWELL. It seems to me we must recognize that research is best done by the best people to do it. It really isn't a question of where it is being done. The principal problem here, I think, is the one you touched upon in your earlier questions—that of being sure that we know where it is all being done. This is what we are moving toward.

Mr. OSMERS. In other words, if we have a weakness, Mr. Newell, it would be at shall we call it a clearinghouse level?

Dr. NEWELL. Yes.

Mr. OSMERS. We need to have the strongest type of liaison and the strongest possible cooperation and exchange of information. Sometimes—not from what I have heard here this morning—but sometimes, Mr. Chairman, I get the opinion that the Nation does not

presently have that. I may be wrong, but it seems to me that we have a lot of things going on that are very, very closely related so far as the country is concerned, but not at all related so far as the people conducting the experiments are concerned.

That is an observation, not a question.

Dr. NEWELL. I might point out that this sort of liaison is being carried out in the various areas, and there has been a close interchange of information and comparison of programs in the vehicles field which you heard described earlier. The same sort of thing is going on in the applications field that you will hear described later.

On the working level we are perfectly familiar with what is going on at various places in the Department of Defense, the Air Force Cambridge Research Center, and so on. We have not yet formalized this liaison. This is what we are moving toward at the present time.

Mr. OSMERS. Mr. Chairman, just one final question, and that would be this: Do you feel, Dr. Newell, having reviewed these figures and considering the matter for an extended period of time, that in general the amounts of money which are called for in the pending bill, are they in your judgment about the right amounts? Should they be much larger? Are they too large? Or how would you express that to the committee?

Dr. NEWELL. At the present time I still have the job of getting the moneys I have available committed. If I get to the point where I need more moneys, I will start making noises.

The CHAIRMAN. Mr. Wolf.

Mr. WOLF. Thank you, Mr. Chairman. I have two questions. One is technical and one is a little academic, perhaps. The first is technical. How do you measure one-billionth of a second? I would like to have you tell me a little bit about that kind of a clock.

Dr. NEWELL. Yes. This is a very interesting kind of clock. It has been referred to as the atomic clock, also the ae clock. Let's describe for example a clock using rubidium vapor. The rubidium metal in vapor form has the property of absorbing radiation in microwave and infrared regions. Very simply what one does is to irradiate this rubidium vapor with a proper infrared light source. This light is then absorbed thereby exciting the rubidium atoms. Then one irradiates the rubidium vapor with radio waves in the microwave region and this has an effect counteracting the infrared effect. By comparing these, one can determine and control the frequency of the microwaves, which accurate frequency is then used as the clock.

The CHAIRMAN. What is your technical question? [Laughter.]

Mr. SISK. If the gentleman will yield, Mr. Chairman, since the gentleman brought that question up here again as a point of interest and maybe it is irrelevant to the money spent here, but you speak of the theory of course of relativity and what possibly this clock experiment, let's say, might prove. It is my understanding that according to the theory it would be the assumption that this clock at this altitude will run faster than it will here on earth.

Assuming that clock reversed that procedure, then to what extent does that affect your feelings as to the theory of relativity as we have understood it here before?

The point I am making, Doctor, is this, is this an attempt to prove or confirm certain theories of relativity?

Dr. NEWELL. Yes; it is an attempt to confirm the general theory of relativity. If we do confirm it, this will be very interesting and very important.

On the other hand, if it turns out that the result shows that the general theory of relativity is wrong, this will be even more interesting. [Laughter.]

Mr. SISK. If I could make an observation, Doctor, I remember very well as a young fellow in college we had a visiting professor come and he got up and the first thing he said was there were only seven men in the world that understood Dr. Einstein's theory. Then I suppose he proceeded to assume that he was one of the seven.

After 2 hours I don't know any more about relativity than I did to start with.

This is an interesting experiment. I look forward to the results with considerable anticipation.

Mr. OSMERS. Mr. Chairman, if the gentleman from California will yield, at least if the theory is disproved, those of us who were never able to understand it will not have wasted any time. [Laughter.]

The CHAIRMAN. I would think after these bright remarks it would be time for you to quit. But Mr. Wolf still wants to ask another question.

Mr. WOLF. I hesitate to ask this now. I am interested in what sort of a yardstick you have to know that you are getting your money's worth when you say you allot a certain amount of money to some institution for research. If you do have a yardstick, will this committee be able to look into this yardstick and after the work is done, to see whether we got our money's worth.

Dr. NEWELL. Yes. This is a very important question. It is a very difficult one to answer in the field of basic research.

In general the only approach you have is to use the thinking and the opinions of people who are recognized as experts on the basis of past performance. In the case of our own program we have been making full use of the National Academy of Sciences' Space Science Board. In reviewing proposals, we contact experts in the particular fields. We go over them ourselves very carefully.

We also analyze the field to be studied, to isolate the important problems and relate proposals to the important problems. The importance of the problems, how you evaluate how the problems are important—this again is a matter of judgment and it is subjective, but again you use the scientists who have had experience in the field.

The final test is the output, the product, the research papers, ideas that come out that can be used for further research, that can be used for practical applications. If we find that a researcher just never turns anything out, then we know we have made a wrong bet and we move to someone else.

On the other hand, if we find that he keeps coming up with good and stimulating ideas and other people find them useful for applications, we know we have made a right choice.

Mr. WOLF. I was going to ask you then: After we have furnished the taxpayers money who gets the patent rights or the copyrights, whichever is involved?

Dr. NEWELL. This is specified in the Space Act. It resides in the Government.

The CHAIRMAN. I would like to ask you something. In the hearings of the select committee something was said about time standing still when you got out into space. Your theory is diametrically opposite to that.

Dr. NEWELL. No, no. It supports this. The theory of relativity——

The CHAIRMAN. The clock runs faster, but your time still stands still. Is that the idea?

Dr. NEWELL. When you think of how you measure time and what you mean by time, you really mean atomic actions and vibrations and things like that. Or if you wish, you could use as your clocks, biological processes, cell division and growth and so on.

On that basis, then, when you think the clocks in a strong gravitational field go slower than clocks in a weak gravitational field, this means that the people in the strong gravitational field at the surface of the earth are living slower, hence aging slower, than those who are out in space in the weaker gravitational field.

The difference, however, is so small that this is not an elixir of life at all.

The CHAIRMAN. You are discarding calendars now; aren't you?

Dr. NEWELL. Yes.

The CHAIRMAN. Any further questions?

Mr. King wishes to ask you a question.

Mr. KING. Dr. Newell, we approach these subjects, of course, with a lot of timidity because we are in a field where we have no expert knowledge. Our job, of course, is to find any fat that can be squeezed out of budgets and naturally it would be presumptuous for us to come in and suggest that there is some fat when we know so little about it. But we have a practical problem. Our problem is to balance the demands of national defense and the exploration and the work that you are engaged in with the demands of economizing.

Dr. NEWELL. Yes.

Mr. KING. Just as a practical matter, look at it from our point of view for a minute. What is our approach to this great problem in our attempt to see whether there may possibly be some areas that could be cut down.

Can you put yourself in our position for just a minute and suggest an approach that we might follow that would be fruitful? Maybe that is an impossible question, but see what is puzzling me and maybe you can help us out.

Dr. NEWELL. I can't really answer the question. It takes a lot of thought. I think the major approach that I could suggest would be to look toward a balanced total program.

If you are in mind to approve a total program in space activities of, say, X billion dollars, then a certain reasonable fraction of that must be devoted to the basic research that permits you to continue your work beyond what you now see.

What I have in the budget here, the $46.7 million, is what we feel is a reasonable fraction of the total NASA program to plow into fundamental research, extending the frontiers of science that is necessary for the future.

Mr. KING. You feel this is a balanced program?

Dr. NEWELL. Yes. This is the basis on which we have approached the development of this program, yes.

Mr. KING. Are the proportions about the same in this program as they are in the atomic energy program or other comparable programs from which we might draw analogies?

Dr. NEWELL. I don't know.

Mr. KING. You have given me good thought. Thank you.

Mr. OSMERS. Mr. Chairman, I wonder if I could ask Dr. Newell a question.

The CHAIRMAN. Mr. Osmers.

Mr. OSMERS. It does not deal with this program or budget, but has considerable to do with the basic question. That is to do with the general question about the American educational system. Dr. Newell, do you feel our basic educational program in the United States—limited to the public portion of that education, the first 12 years of public education—do you feel that that educational program throughout the country is geared to the needs of the age and the Nation at this time?

Dr. NEWELL. Before answering your question, Mr. Congressman, I would like to point out I have a certain competence in this area because one of my advanced degrees is in education.

Mr. OSMERS. That is why I have asked you the question.

Dr. NEWELL. I did spend quite a bit of time teaching. I think there are two problems that need to be met: One, that of providing professional scientists and engineers; and two—and this is not less important—that of providing in the rest of our community an appreciation of what these professional people are doing.

I think in the matter of providing scientists and engineers we are beginning to do what ought to be done. I am not sure that we are going far enough on the other problem.

The CHAIRMAN. Further questions? If not, thank you very much.

Next is Mr. Edgar M. Cortright, who will present the satellite applications.

STATEMENT OF EDGAR M. CORTRIGHT

Mr. CORTRIGHT. Gentlemen, I am sure we are each very eager to see this country exploit its hard-won capabilities in space technology. Fortunately, there are a number of promising applications of satellites which are of interest and importance to all of us. These include communications, meteorology, navigation, and geodetics.

COMMUNICATIONS SATELLITES

Within the past month or so I did have the opportunity of presenting to you the NASA program on communications satellites. I think at least a majority of you gentlemen were here at the time and listened to the discussions by myself and by representatives of the communications industry of this country. However, I am going to review this subject very briefly in case you do want to ask questions at this time.

To first review the motives for such a program, there is a great need in the world today for improved communications in many underdeveloped areas. I think this is obvious. However, even in the developed areas there is a surprising need for improved communications, one which we frequently don't recognize. The transoceanic communications which we have today will be saturated in approximately 1962;

the planned addition of a second telephone cable will not be a solution since it will be saturated before the cable is even installed.

The CHAIRMAN. How many cables are there?

Mr. CORTRIGHT. There is one across the Atlantic for telephone-type communication.

The CHAIRMAN. I saw some figure, 26, I thought.

Mr. CORTRIGHT. My understanding is that for trans-Atlantic commercial telephone there is a 36-channel cable. However, now that you raise the point, I will check it for the record, but I think I am correct.

By 1970 it is predicted that there will be a transoceanic telephone load of 21 million messages a year. At the current rate for a New York to London telephone call of $12 a message, you can see that there is considerable economic potential here. Looking at it in a little more constructive way, there is considerable opportunity for not only handling the extreme volume of communications, but for reducing the unit cost.

When we recognize that a single channel of transatlantic television, which is currently priceless because it is unavailable, is equivalent to 1,000 telephone channels, we can begin to appreciate the problem. Then, just to make it even worse, I would like to point out that the meteorological satellites, which I will be discussing in a minute generate data transmission requirements which approach those of a single channel of television.

So we do have a tremendous need for improved communications. There are a variety of ways we can attack this problem. The conventional approaches would be by cable, by underwater wave guides—that is not even too conventional—by relay towers for ultrahigh frequency, by tropospheric scattering, and by other techniques you may have heard of.

Another approach, which is newer, is the communications satellite, and it is our feeling, and the feeling of many people throughout the country in the communications business, that it is the most promising.

There are two types of communications satellites in which we have a great interest. One of these is the passive communications satellite which you may recall was discussed in considerable detail before. Very simply, the technique here is to use a surface in space, in orbit about the earth, at which we can direct a high-intensity radio beam, and which in turn will reflect that beam back to the surface of the earth. The type shown here is a sphere, and the beam is reflected in all directions so as to give great area coverage, but with a very weak signal. This means that on the receiving end we must have an antenna which is large, can be pointed at the satellite, and has a very low noise receiver connected with it.

This is the first NASA experiment on communications satellites. We will attempt to place into orbit towards the end of this year a 100-foot diameter sphere made of aluminized mylar, weighing approximately 150 pounds rather than the 65 pounds indicated on the chart. We have had to go to a more sturdy material than we first considered, namely, half of one one-thousandth of an inch thick.

This satellite is shown in the next chart in an inflated condition. It is packaged into a 30-inch diameter sphere, and upon injection into orbit, the residual air which we are not able to extract on the ground

begins the expansion process. Beyond that point some water which we deliberately put in vaporizes and thus further inflates the sphere.

The way in which these spheres are used in an ultimate system is indicated on this chart. A single sphere won't do the job, although it is sufficient to conduct cross country communications experiments to determine the characteristics of the sphere and the transmission characteristics on the signals. Here we have shown a dozen equally spaced spheres in a low-inclination orbit just for illustrative purposes. Let's look at the single red sphere. Any two stations within the visible horizon from this sphere can signal each other. For example, this station can signal this one, but as soon as the sphere moves on in its orbit, they lose communication unless another sphere has come into view of both stations. This requires multiple spheres, and sufficient spheres would be put into orbit so that, statistically, 99.9 percent of the time there would be one that could be used.

If we use polar orbits, which are a little more desirable than what I have shown here, we might need as many as 25 spheres at 2,500 to 3,000 miles altitude. This isn't as bad as it sounds from a cost point of view because it is quite probable we can put up as many as 10 at a time with the larger booster systems.

Another type of communications satellite about which you have no doubt heard is the active repeater. This type of satellite would be placed into equatorial orbit at 22,300 miles so as to remain above some spot on the earth. They would be equally spaced and would be attitude-controlled so that their antennas point towards the earth. The technique of communicating from one side of the earth to the other would probably be a double relay in this case, up, down, up, down.

The repeater satellites will probably weigh from 800 to 3,000 pounds. Hopefully, they will use solar cells and have a life of at least 2 to 3 years. Eventually, maybe, we will get some with considerably longer life which would of course be very desirable.

Just to spell out briefly the NASA's role with this type of satellite, the majority of this repeater program is being carried by the Department of Defense at the moment. We are cooperating with them in this program and are budgeting a certain amount of money ourselves to carry on some particular types of development for payloads which are more suited to commercial and civilian use than would be the DOD equipment. The Department of Defense equipment is apt to run heavier than the commercial requirements because it would have antijamming features.

This, then, concludes the review I wanted to make of the communications satellite program. We have budgeted $4.7 million for payload and ground equipment development in 1960. I hasten to point out that the total program combining 1959 and 1960 funds would supply, in addition, six booster vehicles before the end of 1961.

METEOROLOGICAL SATELLITES

In the area of meteorology, the reason the satellite promises to be of such importance is that it offers us for the first time a vehicle which is equal in scope to the problem which faces the meteorologist—namely, surveying the entire mass of the earth's atmosphere on a continuous basis. At the moment perhaps 20 percent of this atmosphere

is sounded each day. There are large portions of the atmosphere, important portions, where storms can reside unbeknown to the meteorologist.

In the first chart I have indicated the type of measurements we hope to make with meteorological satellites. One type—and the most easy to understand—is the observation of clouds. We hope to be able to, and are quite confident we will, determine the overall cloud cover, the types of clouds and the motion of the clouds.

In addition, by applying radar techniques, we hope to measure cloud heights, layers of clouds one above the other, and precipitation which exists beneath the clouds. In addition, by using a technique of detecting electrical discharge from lightning flashes, we hope to be able to locate thunderstorms underneath their blanket of clouds.

In addition, there are various temperatures which we think we will be able to measure—the temperature of the stratosphere, the tropopause, the cloud tops and the surface of the earth. In this regard it is interesting to note that by measuring the temperature of the sea, we can determine the tidal motions which are rather poorly plotted at the moment.

In addition, there is hope of measuring water vapor distribution, ozone, and carbon dioxide, all important constituents from the meteorological point of view.

As Dr. Newell mentioned, we are also interested in what is commonly referred to as the heat balance or heat budget. The atmosphere has trouble balancing its budget also, and it turns out that local imbalances of the incoming solar radiation, the reflected solar radiation, and the reradiated energy, cause forces within the atmosphere trying to equalize this heat distribution; these forces, roughly speaking, actually move the air masses and causes what we commonly think of as weather.

In the next chart I have shown what might constitute an ultimate system. Everyone must have a goal, and this is the type of system at which we are pointing. We are not certain that it will evolve in exactly this manner, but we have some confidence at this time.

This system would utilize a series of low-altitude satellites in the neighborhood of 500 miles, and in polar orbits, perhaps half a dozen, which are equally spaced and which go around in this manner and survey different areas of the world. They give a concentrated survey in the polar regions, and a more dispersed survey at the lower latitudes. This low-altitude satellite would make the detailed measurements that I referred to before—constituents, temperatures, detailed studies of clouds, and so forth.

In addition we envision that in equatorial orbits of 22,300 miles, we would need perhaps four additional satellites which would sit on station above some particular point of the earth. These satellites could be directed by radio instruction from the ground to observe selected regions at the discretion of the meteorologist. For example, with a zoomar lens technique, they could widen their field and locate trouble areas, then narrow down the field of view to examine these storm areas as they develop. This gives a more controlled type observation on an instantaneous basis to the weather observer.

One can imagine, I think, the day when we might see flashed on our television screens, at perhaps fifteen-minute intervals at station

breaks, weather pictures of our own local areas taken from such satellites and interpreted for us by a station interpreter.

A system of this type is not easily arrived at. We must go through a long series of difficult developments, taking smaller steps first before we arrive at anything so elaborate as that system. For example, our first meteorological satellite which was launched in February with a Vanguard rocket is shown here.

This was a cloud cover experiment devised by Mr. William Stroud at the U.S. Army Signal Research and Development Laboratories at Fort Monmouth for the IGY program.

This satellite was designed to determine cloud pictures in the following manner. It utilized photocells which looked out from the satellite in diametrically opposite directions at 45 degrees to the spin axis. Then the spin of the vehicle and its translation causes these fields of view to sweep across the earth and generate a scanned picture much equivalent to your own television sets.

Just to illustrate the type of heartbreak one goes through in this business, this particular satellite, due, we think, to a rough-burning condition in the third stage, had a precession or a wobble introduced, which was built up in the de-spin procedure. As a result, instead of getting regular scans transmitted down to the earth from which we could reconstruct a picture, we get all sorts of crisscross scans, which is making it extremely difficult to generate a picture on the ground.

The next type of meteorological satellite which will be launched——

The CHAIRMAN. You have got nothing of real value from that, have you?

Mr. CORTRIGHT. From a meteorological point of view we have gotten nothing of real value. From a scientific point of view we have learned that the basic photocell technique is generating a good electrical signal, so we have confidence in the technique. Strangely enough, we are learning something about the motion of bodies in orbit in the precessional type of motion, which will help us to avoid this problem in the future.

The next type of satellite will carry heat balance experiment. This is a little detailed. I am going to go through it quickly just to give you the general idea. This satellite uses four spheres on the ends of the antennae, a white one to absorb long wavelengths, a black one to absorb all wavelengths, and two coated spheres to absorb short wavelengths.

In addition, these coated spheres are shielded in a particular manner so that during a portion of the orbit one sees the Sun and one sees the earth. All of these temperature measurements within the spheres are combined electrically so that the signal transmitted to the ground can be interpreted as a measure of the heat balance which I described before. I think that is sufficient description for this experiment.

I have two charts here, which I am going to defer to executive session because they are still classified, showing a more advanced satellite which is scheduled for launch, hopefully, by the first of next year.

This satellite makes use of television as well as infra-red detection equipment. It stores vast amounts of information in the form of pictures and radiation distributions on tape, and these signals are

read out over large antenna stations located in the Northern Hemisphere at two locations.

I would be happy to go through this for you later if you so desire.

There is one launch scheduled by the first of the year, hopefully, and a second one later on towards mid-summer of next year.

The types of pictures that these advanced meteorological satellites might get are illustrated in this chart. This area actually is smaller that that which will be observed by the large field of view camera in this advanced satellite. This is something like 400 by 500 miles, whereas we will be getting one picture 800 miles square.

The clouds shown on this figure were photographed by Naval reconnaissance aircraft flying in parallel over Florida. Actually the satellite picture will show clouds over this whole area. It is very difficult to recreate a cloud structure of this type from isolated ground observations. When we start getting these pictures from altitude we are going to see weather conditions in a manner which we don't quite visualize from the ground-type observations. This illustrates the particular point. Here is a section of a cold front which no doubt extends through like this. The cloud photograph shows it very clearly.

Even the satellites scheduled for the end of this year carrying television cameras etc. are only intermediate satellites. It is necessary to build satellites which are stable in attitude so that the cameras and infra-red equipment photographing the earth are always pointed toward the earth as the satellite goes around. This is a new type vehicle that is going to take considerable research and development effort to arrive at. In our 1960 budget we have asked for $10.8 million, the majority of which will go toward developing this satellite and the ground equipment required to support it.

The CHAIRMAN. What do you call that?

Mr. CORTRIGHT. The satellite?

The CHAIRMAN. The project.

Mr. CORTRIGHT. The one that is already under construction is Tiros.

The CHAIRMAN. That is $10.8 million?

Mr. CORTRIGHT. No. The $10.8 million would go for a project which we have not officially named yet.

GEODETIC AND NAVIGATION SATELLITES

I would like to conclude my discussion of the satellite applications with a brief description of the geodetic and navigational satellite. Dr. Newell described for you the general problem of determining the shape of the earth accurately and some of the significance of this type of measurement.

It applies not only to the general theory of the earth's structure, but has a practical application in that once we determine the shape of the earth we can apply this knowledge to predicting not only missile trajectories more accurately but also satellite trajectories more accurately. This is necessary for the advanced missions which we contemplate.

In addition, there is the problem of surveying the earth accurately. For example, the earth at present is surveyed extremely accurately

in the network shown on this chart—the United States, most of Europe, and a few other selected areas in the world where civilization has been at work.

However, these accuracies are in the neighborhood of 75 feet across a distance like the United States. Continents, however, are tied together only to accuracies of about 1,000 feet. Islands are out of position perhaps in the neighborhood of 1 mile.

The geodetic satellite will enable us to tie these nets together, we think, to accuracies of less than 100 feet. This has significance not only from a scientific point of view but also in the application to ICBM target determination.

The type of satellite which we must use is a heavy satellite which will have a stable orbit, precisely determined. In order to determine an orbit precisely, we feel it is necessary to see the satellite. Hence we have to provide a flashing light and photograph it against the star background.

As indicated in the next chart, by using simultaneous observations from various ground observing stations, we then can tie these stations together to the accuracies I already indicated. There are also ways to extrapolate the orbit with sufficient accuracy to tie more isolated points, where we can locate single cameras, into the network.

Also I have indicated here the fact that the technique used to arrive at the earth's shape accurately is one of dynamical analysis and requires multiple observations of a satellite.

The last chart indicates what this satellite might look like. We now have a study underway to develop the flashing-light system, one which will operate with solar cells combined with batteries, and which will have a long life. There are some severe engineering problems to achieve this. The satellite might weigh in the neighborhood of 100 pounds.

How do we use this in navigation? Actually, what I have been describing, because of the photographic technique required for precise location, is a geodetic satellite. By including radio equipment aboard, however, it can be used for navigational purposes. At the moment the prime program on a navigational satellite resides within the Department of Defense, and we all have great hopes that this type of satellite will permit determining the position of the observer using radio equipment to accuracies of better than one mile—perhaps half a mile. By using the lights combined with the radio equipment we can more precisely determine the orbit and hence increase the probability of achieving these very great accuracies. We are working with the Department of Defense at this time to combine the flashing-light system with the radio system so that each launch might serve both agencies. Thank you.

The CHAIRMAN. Thank you very much, Dr. Cortright.

Mr. CHENOWETH. Mr. Chairman?

The CHAIRMAN. Mr. Chenoweth.

Mr. CHENOWETH. I would like to ask a couple of questions about the communications system, Doctor. Are we approaching anywhere close to a situation where that will have any practical value and would be of any help in solving this tragic situation across the Atlantic which you mentioned?

Mr. CORTRIGHT. I might point out that it doesn't look as though from a telephone transmission point of view this problem will become overpowering until about 1962. So this gives us a little time to do some experimenting and determine just what the best system would be to exploit.

Mr. CHENOWETH. What does it look like to you right now? What are the prospects so far as you can see at the moment?

Mr. CORTRIGHT. We have hopes that the reflective type passive satellite will be usable within that time period. It is even possible that the repeater satellite might, but this is more questionable because the boosters required to put a wide bandwidth repeater satellite in the 22,300 mile orbit are not quite with us yet. There are also some severe technical problems to be solved in the vehicle itself.

So I think that if the reflector satellite works, it will be the first one available and the repeater satellite will come along a little later.

Mr. CHENOWETH. Can they be employed some way in a commercial communications system, then?

Mr. CORTRIGHT. Yes, sir, they can.

Mr. CHENOWETH. You say they can?

Mr. CORTRIGHT. They can. I might mention two points I forgot to mention during the discussion. The reflector satellite has the nice property that it has no equipment on board and it has nothing then to determine the frequencies. So multiple users—that is, many users—can use this satellite subject only to the conventional frequency allocation problem.

The repeater satellite is apt to have fewer channels available and hence would, I think, generate more difficulty in the assignment of users rights.

Mr. CHENOWETH. Do I get the impression, Doctor, then that in the foreseeable future, perhaps within 3 or 4 years, when we make a long-distance call from New York to London we may be using the satellite system?

Mr. CORTRIGHT. I would hesitate to say that in 3 or 4 years you would be doing that. I think the technology will come along to the point that we will be able to do it then. Whether or not the commercial organizations will pick this up and have it in use at that time, I don't know.

Mr. CHENOWETH. How about military applications?

Mr. CORTRIGHT. That is quite probable, although none of us are certain which of the techniques will be the one which is used. There are three approaches. I mentioned two of them—the reflector and the repeater. There is also a mail-bag technique in which you store information as it goes over the sender and read it out as it moves on around the world over the receiver. We don't think it is too exciting from a commercial point of view, but it has definite military application. I am quite sure that in the time period you are talking about you will see the military using equipment of this type.

Mr. CHENOWETH. But it is your considered judgment, then, that this does offer some definite commercial possibilities?

Mr. CORTRIGHT. I am quite convinced of it.

Mr. CHENOWETH. On the weather situation, the meteorological program, you are not quite so confident of that as being of commercial assistance to you?

Mr. CORTRIGHT. The meteorologists will not stick their necks out to the point—and I don't think they should—of saying that this system is going to cure the meteorological ills of weather forecasting. It is wrong, I think, to say that the meteorological satellite is going to immediately yield great improvements in forecasting. It is going to provide another type of data, a type of data which we don't now have, which can be fed into the national meteorological system. In that basis it offers great promise. One thing I think you can say for certain. It will improve storm locating abilities.

Mr. CHENOWETH. Up to this time have you used it to any advantage like that? Have you had any practical value out of it?

Mr. CORTRIGHT. Yes, but with a rocket rather than a satellite. I was rather shocked to see as I went through the charts that I left out one of my favorites when I picked them up this morning, and that was one which showed a cyclonic disturbance (a hurricane) developing down over the gulf coast of Texas. This disturbance was detected with photographs from a rocket firing from White Sands in 1954 to 100 miles altitude. The photograph showed the hurricane up extremely clearly. It had a spiral nebulae-type pattern.

The Weather Bureau, with its ground stations, had been unable to detect this storm. Yet the altitude photograph showed it most clearly. We feel confident that observing satellites will pick up in the regions of the ocean which are poorly covered these cyclonic storms, hurricanes, at the earliest stages of their development.

Mr. CHENOWETH. You say that was in 1954?

Mr. CORTRIGHT. 1954.

Mr. CHENOWETH. What progress have you made since that time? Have you perfected it to any extent?

Mr. CORTRIGHT. No; not really. We have made some additional rocket firings to get more cloud pictures. But rocket people like to fire their rockets in good weather because they are trying to get good shots off for other types of information. We have on a few occasions launched rockets just to get more storm pictures to see what they are going to look like from a satellite.

But the only real possibility of getting enough coverage to make this technique worthwhile on a large scale is with the satellite.

Mr. CHENOWETH. Do you feel, then, eventually it may come to a point where this will have some practical value?

Mr. CORTRIGHT. Yes; I do.

Mr. CHENOWETH. How far away is that, do you think?

Mr. CORTRIGHT. Again one doesn't like to prognosticate too far into the future.

Mr. CHENOWETH. Just approximately.

Mr. CORTRIGHT. It looks as though within a decade we could have an operational satellite system which is used in the daily business of the Weather Bureau and the armed services, possibly before.

Mr. CHENOWETH. The communications, though, you think will probably come first?

Mr. CORTRIGHT. We will be using some weather satellites as we go along, developing the system. Within the next few years we will be getting very useful information from weather satellites; and within the next few years the communications satellites will be usable.

Before you get a complete system, though the longer time periods are required.

Mr. CHENOWETH. Thank you, Doctor. Your presentation has been most interesting.

The CHAIRMAN. Let me ask you this. We have sent up several satellites. Haven't we tried thus far to use that reflector principle on some of the satellites that have been sent up?

Mr. CORTRIGHT. I think not, unless they have tried to get radar signals from some of the larger rocket casings. This, in a sense, is reflecting a radio signal, but for communications purposes the only satellite that has been used is the moon. Certain fundamental experiments in bouncing signals off the moon have been underway for a long time.

The CHAIRMAN. We bounced signals off the moon, haven't we?

Mr. CORTRIGHT. Yes.

The CHAIRMAN. Has it been found practical to use the moon there as an artificial satellite for that purpose?

Mr. CORTRIGHT. Some of these studies are classified, Mr. Brooks. I can say this much, I think, that the moon theoretically is inferior as a reflective satellite to the man-made earth-orbiting satellites at lower altitudes.

The CHAIRMAN. How can you say that when you say we haven't yet tried the manmade satellites?

Mr. CORTRIGHT. I say theoretically. When one computes the power required on the basis of reflectivity and distance, the moon is inferior.

The CHAIRMAN. Wouldn't it be relatively easy to try reflecting sound or waves off of one of these satellites that we put up?

Mr. CORTRIGHT. It depends on what you mean by relatively easy. The experiment which will go up at the end of this year already has underway the preparation of the ground sites to reflect signals from California to the east coast and signals from the east coast to California. We will do this.

The CHAIRMAN. So at that time we hope to be able to send messages up to the satellite and get them bounced back?

Mr. CORTRIGHT. Yes, sir.

The CHAIRMAN. We will start with the east coast and bounce them over the west coast?

Mr. CORTRIGHT. Both ways, at two different frequencies, actually.

The CHAIRMAN. So really that could be the start of a program for use of satellites for communications.

Mr. CORTRIGHT. This is our intent, sir.

The CHAIRMAN. That would be at the end of this year?

Mr. CORTRIGHT. Yes.

The CHAIRMAN. In reference to weather information, it would seem to me in reference to tornadoes that you could get pictures of cloud coverage that would show tornadoes that are up in the clouds and have not come down to the earth.

Mr. CORTRIGHT. This is very difficult, it turns out. One can recognize the types of clouds which breed tornadoes, and by associating these pictures with meteorological conditions which have been established on the ground which are conducive to tornadoes, one can infer that this is a tornado breeding situation.

However, even from aircraft at lower altitudes with higher resolution photography, it is difficult, I am told by the Weather Bureau, to determine whether or not there actually is a tornado under the cloud.

The CHAIRMAN. You can see the tornadoes and you can follow them. Actually the Air Force has followed them in planes. But then they will lift up and go up into the clouds.

Is it your thought that we would be able to take a picture of the cloud from the top or the side level and be able to determine if that tornado is still there or has dissolved?

Mr. CORTRIGHT. I think that this is highly speculative at the moment. We don't have any great confidence that we can photograph tornadoes from satellites, although one is always hopeful.

The CHAIRMAN. Could we put a satellite as low as 100 miles up?

Mr. CORTRIGHT. At 100 miles the life would be too short to make it economical. However, this isn't too critical. One can get the higher resolution by varying the lens focal length and it is possible with zoomar techniques to focus in sharply on certain areas.

The whole question is: What can one see through the clouds in the way of tornadoes?

The CHAIRMAN. If you use the X-ray principle we might see the different levels.

Mr. CORTRIGHT. For example, radar might be able to detect the tornadoes through the clouds. I don't think we are going to know the answer to that one, sir, until we put the radar up and see what we do measure.

The CHAIRMAN. Thank you very much, sir. Mr. Fulton.

Mr. FULTON. You had spoken of a method of research referring to the earth's measurements and a number of the large bodies. I will ask you what you meant. By my recollection of your statement, the extrapolation——

The CHAIRMAN. Excuse me a moment. Mr. Chenoweth, we are going to have a 5-minute executive session here. I believe you will be interested.

Mr. CHENOWETH. Right away?

The CHAIRMAN. Just as soon as Mr. Fulton is finished; yes. I think you will be interested.

Mr. CHENOWETH. Thank you.

Mr. FULTON. Extrapolation of the earth's measurements would require dynamical research. My question is, the word "dynamic" of course means in physics relating to energy or force or heat. In mechanics it would mean the motion of bodies.

What do you mean by that? Are you speaking of the earth? I don't understand you. What do you mean by that?

Mr. CORTRIGHT. I was referring to the uneven motion of the satellite in orbit; the regular motion is perturbed by irregularities in the shape of the earth's geoid or surface.

Mr. FULTON. So you were speaking of the motion of the satellite in relation to the movement of the body, the earth. Is that what you meant by your statement? It is a little complicated, and I don't think you made yourself clear.

Mr. CORTRIGHT. I probably didn't. If the earth were perfectly spherical, and we had a satellite in a circular orbit, it would go around indefinitely in a circular orbit. If the earth is distorted, then the orbit is disturbed.

Mr. FULTON. So you were really saying in relation to the earth, this satellite that we want to have up there stationary is not really stationary because of the distortion of the earth's surface; it seems to move. Is that what you meant?

Mr. CORTRIGHT. No. This discussion was with regard to the geodetic satellite, which, by the very virtue of observing these irregular motions is being used to establish the shape of the earth.

Mr. FULTON. It is then in regard to the measurement of the earth's surface and not in regard to the stationary satellite?

Mr. CORTRIGHT. Yes.

Mr. FULTON. But that brought me to my point: Does the stationary satellite then seem to move under these principles because of the fact that the earth is not round? Will that seem to have a change in its orbit in relation to a spot on the earth's surface because the earth is elongated, pear shaped?

Mr. CORTRIGHT. No, if the earth is symmetrical about its axis. Actually I am saying this wrong still. The fact that the satellite is fixed relative to a suborbital point on the earth's surface would mean that it would not be disturbed in orbit to the best of my knowledge by irregularities in the earth's shape.

Mr. FULTON. So that the shape of the earth has no effect on the fixed satellite that is orbiting at the Equator?

Mr. CORTRIGHT. I think that is roughly correct.

Mr. FULTON. Thank you.

The CHAIRMAN. Thank you very much, sir.

At this time the committee will go into executive session and hear Mr. Milton Rosen on the Project Centaur, which is classified.

We will resume in open session at 2:30 this afternoon.

(Whereupon, at 12:10 p.m., the committee went into executive session.)

AFTERNOON SESSION

The CHAIRMAN. When we recessed at noon we had just heard from Mr. Milton Rosen, who spoke regarding the Project Centaur in the executive session.

Next on the list of witnesses is Mr. George M. Low, who is to brief us on manned space flight. Mr. Low.

STATEMENT OF GEORGE M. LOW

Mr. LOW. Mr. Chairman, members of the committee, in previous testimony before this committee we have outlined our long-range goals in the manned space flight program. We have also given a technical description of Project Mercury which is our manned satellite project.

Yesterday you saw a short film of some of the current flight tests being performed in connection with Project Mercury. Today I will add to this earlier testimony in two areas. First, I will review the present status of Project Mercury, and then I will discuss our future plans for Project Mercury with particular emphasis on our flight test operations.

My first chart is one you have seen before. I will therefore not dwell on it. It shows the satellite vehicle or the ballistic capsule in which man will be flown into orbit. Let me just say now that the

capsule will be about 7 feet in diameter, perhaps 9 feet high, and it will weigh about a ton.

Within the capsule we have a pressure-tight vessel, and in this vessel the pilot is supported in a form-fitting couch. This couch enables him to tolerate the high accelerations that he must endure during launch, and the high decelerations of reentry.

After an industrywide competition, we placed a contract for the Mercury capsules with the McDonnell Aircraft Corp. during January of this year. Since then McDonnell has completed an engineering mockup of this capsule; the engineering, design effort, and construction of some of the components in the capsule are now proceeding at full speed.

The capsule will be launched into orbit with the Atlas booster. Launch will take place from Cape Canaveral, and the Atlas will take the vehicle into orbit at an altitude of between 100 and 120 miles. This is well below the altitude of the Van Allen radiation belt, so that we have no radiation problems in this mission.

After a predetermined number of orbits—2, 3, or perhaps as many as 18 orbits, which is the same as traveling around the earth for a full day—the capsule will be brought back out of orbit by firing the small retrorockets, which you see at the base of the capsule. The capsule then descends toward the atmosphere. The retrorockets are then jettisoned, and the satellite is slowed down by the aerodynamic drag, or the air forces, acting on it.

Once it has been slowed down to about the speed of sound, a series of parachutes will be deployed. First, a small parachute which is not shown here and, finally, a main parachute which will drop the capsule down toward the ocean at a fairly slow speed.

There are many new developments that we must complete before the Project Mercury plan can be brought to its fulfillment. Although we are trying to stay within the present state of the art as far as possible, we still must perform many tests on the various components.

For example, we have embarked on a very extensive wind tunnel program to test the satellite in combination with the boosters, or the satellite in combination with the escape system to simulate the launch phases. We also are testing, in our wind tunnels, the satellite under the same conditions as it will undergo during reentry into the atmosphere.

In addition to the wind tunnel program, we also have a flight test program.

Mr. FULTON. Before you leave that, I have a question, Mr. Chairman. The question comes up when you have retrorockets to slow down the vehicle on its reentry to the atmosphere, or for reentry, a retrorocket will be ejecting a hot stream forward and possibly that might be 3,000° to 5,000° in temperature.

How do you protect the man or the capsule which is probably going to be encircled by that amount of heat when you fire the retrorocket? Or do you have some sort of arrangement to vector the heat away from the capsule?

Mr. LOW. The rocket blast will go away from the capsule. In addition, the capsule does have heat protection all around it. It has a heat shield at the front face which is used to take up the heat as it enters the atmosphere.

Mr. FULTON. Won't the capsule, though, be traveling in the field of the exhaust of the retrorockets? If so, how long? That to me would be a very hot exhaust in the field it would be traveling in. I wonder how you are going to protect the man from that kind of heat.

Mr. LOW. Our calculations indicate that the heat will not affect the capsule to any extent.

Mr. FULTON. How hot will it be?

Mr. LOW. The temperature rise due to the retrorockets will be minor—only a few degrees. After the capsule enters the atmosphere, the heat shield temperature will rise to about 1,500 degrees.

Mr. FULTON. Do the rockets finish their function before the capsule enters any appreciable atmosphere?

Mr. LOW. Yes, they do. The rockets fire at the orbital altitude, and they fire only for a matter of a few seconds.

Mr. FULTON. Directionally speaking, could I ask you, do the retrorockets fire in a straight line trajectory ahead of the capsule, or are they vectored at an angle?

Mr. LOW. They will be vectored up at this angle [illustrating].

Mr. FULTON. So they will be vectored on an inclined plane away from the Earth's circumference, is that right?

Mr. LOW. Yes, they will.

Mr. FULTON. What would that angle be?

Mr. LOW. About 45 degrees.

Mr. FULTON. Thank you. Actually, a trajectory then is under the exhaust of the retrorockets as far as the earth is concerned. Is that not right?

Mr. LOW. Yes, it is.

Mr. FULTON. So it doesn't really travel in this hot flame. It is traveling under it.

Mr. LOW. That is correct.

Mr. FULTON. Thank you.

The CHAIRMAN. Another question—since we started questioning: When you use that retrorocket it contemplates that you must have had a stabilized satellite. Isn't that right?

Mr. LOW. That is correct.

The CHAIRMAN. Without that, your retrorocket might be pushing it forward?

Mr. LOW. The attitude of the satellite will be stabilized with some small jets that are shown on my first chart—jets located at the top of the satellite to stabilize it in two directions, and roll jets at the bottom to keep it from rolling.

The CHAIRMAN. The stabilizer like you have in an airplane wouldn't help you on that, would it?

Mr. LOW. No, it would not, because there is no atmosphere.

The CHAIRMAN. Does that operate on atmosphere or on centrifugal force?

Mr. LOW. This is a gas jet. Each one of the stabilizers in effect is a small gas jet. If I may take this model—some of the jets are located back here. If a jet ejects a gas at this point, then it will tip the satellite in this direction [illustrating]. Or if the satellite should be tipped in this direction, then a jet at this point can straighten it out again.

Mr. FULTON. Just on that point the chairman asked about: Where would the retrorockets be fixed on that kind of a confirmation?

Mr. LOW. They are fixed at this end, on the heat shield.

Mr. FULTON. Then in flight, as you are approaching a deceleration point, how do you eject the retrorockets so they get out of the road?

Mr. LOW. They are attached to the side of the capsule with metal straps. After they have been fired, some small explosive bolts will separate the straps and then the rocket is no longer attached. Presumably it will fall away in one direction or the other.

Mr. FULTON. So that it doesn't really move out of the path of the capsule by any force you generate in it. It will be just by the mere change of the speeds that you give the capsule that causes them to move at a different rate of speed.

The retrorockets will have a constant speed in orbit, and your capsule will have a decelerated speed; is that not right?

Mr. LOW. If these rockets are no longer attached, then as we start entering the atmosphere, more air forces will act on the capsule than on these rockets. So it will actually drop behind the retrorockets in this manner. [Illustrating with model.]

Mr. FULTON. Because it is in front—we will call it, of the trajectory of the capsule—why wouldn't the more atmosphere you get cause the pressure that would hold the retrorocket right against the capsule and it wouldn't do what you say?

Mr. LOW. Because the wind forces acting on it would then also slide it off.

Mr. FULTON. Thank you.

Mr. SISK. Mr. Chairman?

The CHAIRMAN. Mr. Sisk.

Mr. SISK. Is this capsule prone to spin? If so, what is your correction for spin action?

Mr. LOW. There are small jets on the side that will keep it from spinning and keep its attitude controlled in a given direction.

Mr. SISK. Will it be prone to spin? Is there a problem in actual spin action?

Mr. LOW. Not of its own accord.

The CHAIRMAN. Proceed, sir.

Mr. LOW. I started to mention that we are now also in the midst of a flight test program. You saw a short movie yesterday of some of our parachute tests. In these tests we drop full-scale capsules—not the final capsules that will be made by McDonnell, but simplified capsules made out of sheet metal or boilerplate, yet nevertheless duplicating the weight and the shape of the final capsule. We drop these capsules out of C-130 aircraft at high altitude. The capsule then starts dropping toward the ground. First a small parachute is deployed, and finally the main parachute is deployed. As you see in the last picture, the capsule lands in the ocean. The capsule is then carried back to shore with a helicopter.

These tests help us determine the reliability of the parachute system and we plan to perform very many of these tests before the actual capsule is flown from the Atlas booster.

I might also add that there are two main parachute systems in the capsule. If one of the parachutes should fail, there is a second, independent system that will come into action automatically.

Mr. FULTON. At what level or height is there enough pressure to cause the parachute to react?

Mr. LOW. The main parachute will be deployed at about 10,000-foot altitude.

Mr. FULTON. When do you have the first small one then?

Mr. LOW. At about 70,000 feet.

The CHAIRMAN. 70,000?

Mr. LOW. 70,000-foot altitude.

The CHAIRMAN. The main one, though at 10,000.

Mr. LOW. The main one at 10,000.

The CHAIRMAN. It takes 60,000 feet to bring it out?

Mr. LOW. No, sir. The small parachute slows the capsule somewhat and also it tends to stabilize it while it is dropping in the atmosphere. Without a small parachute, the capsule would oscillate, as you saw in one of the pictures. The small parachute keeps it coming down in a uniform motion. Only after it has descended to about 10,000 feet do we start the deployment of the main parachute; this only takes a few hundred feet to come out.

Mr. FULTON. At what speed is the capsule moving when the small parachute first takes effect?

Mr. LOW. At about the speed of sound, which is about 600 to 700 miles an hour at that altitude.

Mr. FULTON. At 70,000 feet. At what speed is the capsule going when the major, large parachute opens?

Mr. LOW. About one-quarter the speed of sound, which is perhaps 150 miles an hour.

Mr. FULTON. Why don't you have vanes or surfaces or modified wing structures that would start slowing the capsule down before you come to this parachute stage? Say a glider principle? Why don't you do that?

Mr. LOW. Because we are employing, in the Mercury concept, the simplest possible approach. We believe that it is much easier to build and to check out and to fly reliably a so-called ballistic shape that has no wings, than it would be to fly an airplane-type craft.

All the ballistic missile nose cone experience is available in building this capsule. Yet, so far there is no experience with airplane-type structures at the very high velocities at which this satellite will enter the atmosphere.

Mr. FULTON. But my point is, Why don't you have the capability of a glide pattern with some sort of basic wing structure or fin rudder structure? Why isn't it a combination of the two?

Mr. LOW. We believe that any lifting vehicle would be the next step after Mercury. The tests that would have to be performed with the tail structures or the wing structures that you mentioned, Mr. Fulton, would delay this project by a considerable period of time. We feel that we can do the job safely with this type of structure in the shortest period of time.

Mr. FULTON. On a plane pickup, you might be able to have something that would glide for quite a distance and you would be able to chase it rather than something that is just descending vertically with only a vector caused by wind.

The time that you have in reentering the atmosphere is so short before the man hits the sea that I wonder why you don't, when you

get below the level of high heating in relation to the speed, have some sort of a structure that he could turn it into somewhat of a modified glide and give you time to pick him up.

Mr. Low. Because any structure like that would add a great deal of complication to the vehicle. One of the main objectives of Project Mercury is to achieve orbital flight and successful recovery of a manned vehicle in the shortest period of time.

If we added wings, or any other innovation, the project would take much longer than it will take with a ballistic, nonlifting, satellite.

Mr. Fulton. Had you thought of a kite or some sort of a drag method that might be outlined to operate as a drag? For example, he might eject some foam styrene or something of that type and make sort of a big air bubble that would slow him. Have you ever thought of things like that?

Mr. Low. Many, many different schemes, such as large metal parachutes or balloons to slow the vehicle down and to help control its flight path were considered. But we believe that each one of these systems would be more complicated than the system that we are now building.

Mr. Fulton. Is the time when the man first is in the capsule and supported by a parachute long enough for you before he hits the sea, so that you can reasonably say the man's safety is well assured?

Mr. Low. The capsule will float in water and we do not plan to snatch the capsule out of the air. The capsule will land in water, where it will float and then be picked up by ship.

Mr. Fulton. Why are the tests to pick up these things in the air being carried on by planes in the Pacific?

Mr. Low. That is part of a military project employing a different concept than ours.

Mr. Fulton. Thank you.

The Chairman. Just proceed, sir.

Mr. Low. Another form of test that we have initiated is a test of the escape system. I mentioned earlier, I believe, that on top of the capsule sits a towerlike structure topped with a solid fuel rocket. If a malfunction should occur during the early phases of launching operation, the capsule would be carried away from the Atlas booster with this escape rocket. It would be carried to altitude, then the parachute is deployed, and it again would land in water.

The escape system is one of the systems that must be completely reliable before we can complete the Mercury mission. We are therefore testing the escape system without the Atlas booster by launching the capsule with the escape system from the beach at Wallaps Island. So far we have completed two of these tests and you saw movies of these tests yesterday. The first one of the tests was not successful due to a failure in one of the rocket nozzles.

The second test, which was performed 1 week ago today, was completely successful. In a period of about 5 minutes the capsule was launched with the escape rocket. It coasted to altitude. The escape rocket was disconnected and the parachutes deployed; it landed on water and was carried back to the beach by helicopter.

Again we are going to perform many more of these tests before the final system is completed.

Mr. Fulton. What is your top altitude there?

Mr. Low. If an escape should occur from the pad, the top altitude is between 2,000 and 3,000 feet.

Mr. FULTON. What is the lateral distance?

Mr. Low. Several hundred feet. The rocket is tilted in order to carry it away.

Following these early tests we will have a number of tests with rocket flight test vehicles. These vehicles, are shown on the next chart. The first is a cluster of four solid propellent Sergeant rockets. This small vehicle, incidentally, we have nicknamed "Little Joe."

We will also have tests using the Redstone booster, the Jupiter booster, and the Atlas booster. All of these vehicles will fly full-scale capsules in up and down or ballistic trajectories before the final satellite mission is undertaken with the Atlas.

Mr. FULTON. Are men in those intermediate stages?

Mr. Low. There will be a man in some of the Redstone flights provided the system is completely reliable.

Mr. FULTON. But not in the Jupiter?

Mr. Low. Not in the Jupiter.

Mr. FULTON. Why the Redstone?

Mr. Low. Redstone has the most flight experience of any of our ballistic missiles. It is an inherently stable vehicle because it has aerodynamic surfaces. We believe it is the vehicle that will be available at the earliest for manned flights.

Mr. FULTON. It isn't because the Jupiter has only a 70-percent capability at the present time?

Mr. Low. Our decision was largely based on other factors. I think I can best explain the purpose of the manned missions with the aid of the next chart, if I may.

On this chart I have the various ballistic trajectories of all the boosters. We see that both the Redstone and the Little Joe vehicle duplicates a portion of the final Atlas trajectory in the early phases of flight. Both of these trajectories then go over the top and give a period of about 4 minutes of weightlessness. Then they reenter the atmosphere and simulate some of the loads that will be encountered in the final orbital mission.

In order to qualify the pilot, and to train him—to give him some of the experience that he will finally get in the orbital mission—we believe he should undergo some of the stresses he will be subjected to in an orbital mission. These include launching accelerations, the decelerations during reentry, the use of the attitude control and the stabilization systems, and a short period of weightlessness.

All of this can be achieved with the Redstone boosted capsule.

The CHAIRMAN. You are referring now to a man in space with the Redstone?

Mr. Low. I am referring to a short-range manned flight with the Redstone, not satellite flight with the Redstone. These flights will be undertaken only after we have made many tests with the Redstone and the McDonnell capsule, first with only instruments, later on perhaps with animals, and only after the system has proven completely reliable will a man be flown in the Redstone tests.

The CHAIRMAN. Will you get about the same thing with the X–15?

Mr. Low. I believe you can get about the same period of weightlessness with the X–15.

The CHAIRMAN. You will get about the same experience then, wouldn't you?

Mr. LOW. You would not have the high accelerations during launch, nor the decelerations during reentry. This is important experience, also.

The CHAIRMAN. You would have a reentry problem, however, wouldn't you?

Mr. LOW. You would not have the heating problem of reentry because at these relatively slow speeds no great amount of heat will be given off to the capsule.

The CHAIRMAN. At least you have the possibility of two types of man-in-space experiments, don't you?

Mr. LOW. That is correct. The first experiments will be pilot training flights using the Redstone booster.

The CHAIRMAN. It will be a thrust type, and the other will be a flight type.

Mr. LOW. The X–15 experience will be more of an airplane flight-type experience.

Mr. FULTON. Every one of those trajectories that you have indicated appears to be a ballistic trajectory. You would not then be experimenting with a gravity turn or any kind of a directional device on any of these preliminary experiments, would you? And it would only be on the orbital vehicle that you would get into the place where you would try to get a horizontal thrust with any upper stages of rockets.

Mr. LOW. That is correct, although there would be some thrust vectoring in the early portions of the flight with all of these vehicles in order to put them into the desired ballistic trajectory.

Mr. FULTON. How does the missile get out of the perpendicular trajectory over into a horizontal——

Mr. LOW. With its own autopilot, which is the same autopilot that is used on the ballistic missile flights.

Mr. FULTON. So that it is not a straight ballistic missile trajectory the way you have said earlier. It is partly a controlled and a directional flight even in the early stages, isn't it?

Mr. LOW. It is controlled in the same manner as a ballistic missile would also be controlled.

Mr. FULTON. I don't see that.

Mr. LOW. The autopilot in, say, the Redstone would start leaning the Redstone over so that it would go in exactly the desired trajectory.

Mr. FULTON. But of course when the autopilot is working it is not a ballistic trajectory.

Mr. LOW. The ballistic part of the flight is after the booster burns out.

Mr. FULTON. I see. Before the booster burns out you really are giving it direction with an autopilot?

Mr. LOW. That is correct.

Mr. FULTON. Thank you.

The CHAIRMAN. Just go ahead, sir.

Mr. LOW. The solid rocket cluster will be used with our simplified capsules in some early tests to establish design criteria for the McDonnell capsule. With the Redstone we will use only the final hardware, the McDonnell capsule.

The Jupiter has a capability of approaching somewhat closer to the satellite velocity than the Redstone or the small vehicle can; it will be used to simulate some of the launch portions of the flight and some of the heating problems or reentry. It will also be used to simulate the worst loads that could be encountered by the orbital vehicle.

We also plan to use the Atlas for ballistic shots before the Atlas is used for orbital shots.

Early flights with the Atlas will take the capsule to the satellite speed of 17,000 miles an hour, but instead of going into an orbit, the satellite will be brought back down again immediately. In this manner we can check some of the heating that will be encountered in the final reentry without going to the complication of completely circling the Earth.

Finally, the Atlas will also be used to boost the satellite into its orbit. I think I should add once again that, as far as the ballistic flights are concerned, the plan is to have manned Redstone flights, but man will not be used in any of the other ballistic flight vehicles.

Mr. FULTON. How long and how far would the Atlas-manned vehicle really be in orbit? How long would it have an orbital path and how far would it be? How far will he go in that orbit?

Mr. LOW. The Atlas ballistic vehicles will travel a distance of 1,700 miles.

Mr. FULTON. How far would you have a man in orbit then on that 1,700 miles?

The CHAIRMAN. He will be operating 11,000 miles per hour. Isn't that right?

Mr. LOW. The Atlas will boost the satellite to 17,000 miles an hour. I should add again, there will be no man in these ballistic Atlas flights. These will be just instrumented flights to check some of the hardware.

The CHAIRMAN. A manned flight wouldn't be above 11,000 miles per hour?

Mr. LOW. The manned flights in the Redstone will be at 4,000 miles an hour.

Mr. FULTON. That is a good point. Then as the chairman points out, with a man, you then jump him into orbit. You don't take him through the successive stages of Jupiter and Atlas and ballistic flight?

Mr. LOW. That is correct, except that the accelerations during launch and the decelerations during reentry with the Redstone will be almost as severe as those in the orbital flight. So he will get much of the necessary experience even in this short a flight.

Mr. FULTON. But the man in space, when he is up there in the capsule the first time, is really going to be shot in orbit around the earth, not just in a ballistic missile flight.

Mr. LOW. The first manned Atlas flights will be orbital flights around the earth.

The orbital flight paths are shown on the next chart. As I mentioned earlier, the launch will be from Cape Canaveral in a direction slightly north of east. Orbit injection will take place near Bermuda and, in the early stages of our program, the satellite will circle the earth three times. On the third orbit the retrorockets will be fired slightly west of the California coast. The satellite will then descend

toward the atmosphere, will enter the atmosphere, and will land in the ocean along the Atlantic Missile Range.

The CHAIRMAN. Will it land in the ocean or the Gulf of Mexico?

Mr. LOW. It will land in the ocean.

The CHAIRMAN. Why do you use east-to-west satellite? Why not use a polar satellite?

Mr. LOW. The earth's rotation in the easterly direction helps us boost the weight into orbit. It imparts additional velocity to the satellite which is necessary in order to lift the heavy satellite into orbit.

The CHAIRMAN. It is the same principle as a plane taking off into the wind. It is lifted up, is it?

Mr. LOW. Essentially that is correct.

Mr. FULTON. How much weight-lifting power do you gain by that additional 1,100 miles an hour velocity?

Mr. LOW. I am not sure of that answer. It is a very important part of it. It corresponds to about 1,000 miles an hour.

Mr. FULTON. On the velocity, I thought if you would give us the pattern of the gain you get on the weight, I would like to have it for the record.

Mr. LOW. We will add it.

(The information is as follows:)

An easterly launch with Project Mercury would give you a capability of orbiting 1,800 pounds more than if the identical firing were made in a polar orbit.

The CHAIRMAN. By the same token, though, are you in better shape bringing it back into the atmosphere on that sort of orbit than you would be if you were making a polar orbit?

Mr. LOW. This is very important in that we can track the satellite continuously as it reenters the atmosphere in order to pinpoint the landing spot.

The CHAIRMAN. The real reason is to track him because you have got these track stations set up.

Mr. LOW. Yes, sir. While in orbit, the capsule will be tracked at many stations and the man will be able to communicate periodically with ground stations. Also data will be telemetered back to various stations.

The CHAIRMAN. In the orbit why does he go below the Equator and then north of the Equator and then down again below the Equator?

Mr. LOW. This would be easier to visualize if we had a sphere and showed the orbit as a line about that sphere. Actually this orbit corresponds to a line in a plane passing through the center of the earth.

The CHAIRMAN. So it is not above and below the Equator. It is all in one position relative to the Equator?

Mr. LOW. The orbit plane intersects the Equator at an angle.

Mr. FULTON. Could you tell us when the Redstone manned test flights will begin?

Mr. LOW. I cannot tell you exactly when the manned flights will begin because we don't know this. This will depend on the reliability of the system. I do have a chart later on that shows our overall program. If I may defer the answer to that question until then, I would like to.

Mr. FULTON. Or about when?

Mr. Low. The unmanned Redstone flights are now scheduled to start in the early part of 1960. I cannot predict the date of the first manned flights because I don't know how long it will take before a man can be flown safely. It will not be in the early Redstone flights.

Mr. FULTON. Where will these Redstone flights be?

Mr. Low. They will be from Cape Canaveral, about 100 miles downrange.

Mr. FULTON. Picking them up in the water?

Mr. Low. That is correct. I think I should add also that even the early 1960 date for the Redstone flight should be considered a target date only, because many things can happen before that time that will delay these flights.

I would like to talk briefly also about our pilot selection. As you all know, we have recently completed this phase of the program. In selecting our pilots, we first listed the activities that the pilot would have to undergo. We feel that, although the Mercury vehicle could fly completely automatically, the pilot will play a very important role in the mission. Mercury essentially is a flying machine, and if anything should go wrong, the pilot has the best capability of correcting this.

In particular the pilot will communicate with the ground stations. He will make scientific observations. He will monitor all the onboard equipment and make corrections as required. He can control the attitude of the capsule. This means that he can manually change the position of the capsule in orbit so that he can look up, down, or any way he desires.

He can navigate in the sense that he has a periscope which allows him to detect exactly where he is and to predict where he is going to be after a certain period of time. Since he can control his attitude and he can navigate, he can then also fire the retrorockets; he can do this even if he should lose all contact with the ground, which is a situation we don't expect to happen. He can initiate other emergency procedures, such as activating the escape system if he has to, and he can deploy the landing parachute if it is not deployed automatically.

Because these functions are so very much like the functions that engineering test pilots perform in their everyday life, we limited participation in the program to this group. The criteria used in the pilot selection are listed in the next chart.

The man must be less than 40. He should be a reasonably young man, yet he should be sufficiently experienced so that he can contribute to this mission.

He has to be less than 5 foot 11 inches tall in order to fit within the capsule. He must, of course, be in excellent physical condition and have a bachelor's degree. He must be a graduate of a test pilot school with at least 1,500 hours total flying time, including jet qualification.

The CHAIRMAN. Why do they have to be married men?

Mr. Low. It turns out, Mr. Chairman, that almost all of the men who meet the selection criteria are married.

The CHAIRMAN. They have a number of children, too.

Mr. Low. Most of the candidates had a large number of children also.

The CHAIRMAN. I suppose you want cautious men.

Mr. FULTON. Why do they have to have a bachelor's degree? Will you tell me why that is necessary in space?

Mr. LOW. We felt that for this mission, for Project Mercury, the man would make important scientific observations that had never been made before by man. He should also be capable of contributing to the engineering systems that are now being developed for Project Mercury.

Mr. FULTON. So it must be a bachelor's degree in engineering sciences?

Mr. LOW. Engineering and sciences, or the equivalent. He may have taken a large number of engineering courses since graduation.

Mr. FULTON. You know it is one of the greatest marvels to me on the accidental circumstance that there happened to be three Navy men, three Air Force men, and one Marine, that their qualifications exactly hit in order to get such a wonderful balance between the services.

I might also add that as far as the Army is concerned, I don't see why they were left out when it is going to be an Army Redstone vehicle, run by Army people, researched by Army peeople, and run under the ABMA. Why are they left out? Why not three Army men?

Mr. MILLER. There aren't three Army men qualified as jet pilots, are there?

Mr. LOW. That is it exactly. We established the qualifications before we knew which of the services would have qualified candidates. These qualifications were established because we believed that the men must be so qualified in order to successfully complete the mission.

The CHAIRMAN. Is it because the Army does not operate jets?

Mr. LOW. The Army does not operate jets, and therefore they were ruled out—after the fact, though. We did not intend to rule them out by any means.

Mr. FULTON. As a Navy man that certainly was a wonderful standard to rule out all Army men and divide it among the Air Force, Navy, and the Marines.

The CHAIRMAN. Did you have any protests from the Army on that?

Mr. LOW. Not that I know of.

Mr. FULTON. You are getting one from the Navy. I think it was obviously a deal, an arrangement, that there were to be three in the Air Force, three in the Navy, one in the Marines. How did that ever happen? It is just such a coincidence.

Mr. LOW. May I go into the selection procedure in greater detail?

Mr. FULTON. It is such a coincidence that it would occur just like that.

Mr. LOW. It is a coincidence, but it just turned out that way.

Mr. FULTON. No deal?

Mr. LOW. No deal.

Mr. FULTON. You mean to say that the selection turned up three in the Air Force, three in the Navy, and one in the Marine Corps, in that proportion, without any slant toward dividing them equally between the services, and certainly a little according to the numbers?

Mr. LOW. In most of the selections we did not work with names or services. We assigned numbers to these men, and didn't really

know until after we had selected the final seven what service they were in.

Mr. FULTON. As a Navy man, may I say you certainly have the standards rigged so you effectively dealt the Army out for a big zero on the honor of getting first into space. Why is it necessary to be a qualified jet pilot other than to pull a couple of levers when emergencies might arise? Nobody has ever been in space before.

Mr. LOW. No, but there will be many unusual situations we can't forecast. This machine is flying at 18,000 miles an hour through space. It may become disoriented through, for example, the last kick of the rocket. The experienced jet pilot gets into situations every day where he is not oriented and he has the knack, and the qualifications, to immediately right himself again; he knows which end is up and how to reorient himself.

He has to operate a control stick which is very similar to the stick on the jet airplane. We felt that in order to insure the success of this mission we should consider only the qualified engineering test pilot, the jet pilot, for the first mission.

Later on, as we learn more about space flight, I am sure we will be able to relax our standards. But I should also say that we did not intend to favor one of the services over another one. Our main purpose was to make the mission a success.

Mr. ANFUSO. Will you yield there a minute?

Mr. FULTON. I will be glad to yield.

Mr. ANFUSO. If the Army were to conduct a test and if they came up with one, two, or three men who met these qualifications, would you have any objection to those men joining this team?

Mr. LOW. I think at this time, and for the first flight, our selection has been completed and these men are now going into training.

Mr. ANFUSO. It is beyond alteration?

Mr. LOW. If we added more names to our list now——

Dr. DRYDEN. May I take over, George? Mr. Anfuso, there has been great interest in this project all over the country. There are any number of young men who want to do this. There are some people even working for NASA who would like to be the first man in space.

I think we have taken a perfectly hardboiled attitude to assure the success of this mission. We wrote the requirements without regard to any particular source. We did begin with the test pilot schools, and we found that 80 percent of the graduates of these schools were interested in going ahead.

We are embarrassed by the number of qualified people—if you like—who could participate in this mission. I think we would not be willing to reopen this question. We have seven men who are going to live with this project, who are going to participate in the engineering development of the parts.

They are going to be as familiar with the inside of this capsule and everything that is in it as you are familiar with your home and everything that is in it.

Mr. ANFUSO. May I ask you this, Dr. Dryden. How many applications did you receive all told?

Dr. DRYDEN. They were not applications in that sense.

Mr. ANFUSO. Volunteers?

Dr. DRYDEN. I haven't kept a record of the number of letters. There were any number of them. These are generally people attracted by the desire to be first. We don't know which of these men will be first. This will be a selection by lot when the first flight comes.

Mr. ANFUSO. The Army was well aware of the method of selection?

Dr. DRYDEN. We have actually, as I recall——

Mr. LOW. The Army participated in the selection.

Dr. DRYDEN. Doctors from the Army are on the team.

Mr. FULTON. The point is this. When there are many young men who want to be first in space, my point has been first that it shouldn't be just military people who are selected. You tell me you didn't even look at some of the applications that came in. Those fellows might have fulfilled every one of these requirements and just not been in an organized military service.

Secondly, it is obvious that there has been a deal or an arrangement made that the Navy and the Air Force get equal, and the Army get none—and the Marines get one——

Dr. DRYDEN. I deny this, Mr. Fulton. It is not so.

Mr. FULTON. Just let me finish.

The CHAIRMAN. I don't believe you can say that a deal has been made. There is nothing here to show a deal has been made.

Mr. FULTON. It is the greatest coincidence in the world, otherwise.

Dr. DRYDEN. We have the responsibility for the success of this mission. As long as we have that responsibility, we are going to exercise it in the way which we think will make it successful.

Mr. MILLER. You in NASA have some very highly qualified pilots that could most likely have qualified.

Dr. DRYDEN. As a matter of fact, one of them actually took these tests and he was in the final group, but we have ruled this out for obvious reasons.

The CHAIRMAN. Let me say this, too, Doctor, that you have a tremendous responsibility. When you send a man up in space for the first time, you have a terrific responsibility. You have the life of that individual at your order.

Dr. DRYDEN. With the whole world watching.

The CHAIRMAN. I think no politics or no outside ulterior consideration should take part in it.

Mr. MILLER. I think anyone who knows Dr. Dryden——

The CHAIRMAN. I have complete confidence in Dr. Dryden.

Mr. MILLER. Would not entertain that at all.

The CHAIRMAN. I merely say that in reference to selection.

Mr. FULTON. My point is, Mr. Chairman, I want every young man in the country with these qualifications to have the chance to qualify——

Dr. DRYDEN. We haven't the time or the money to do that.

Mr. FULTON. And not just arbitrarily have them not be considered or to ignore any individual in the Army who wants to have the test or anybody in NASA or any scientific institution.

Mr. SISK. Mr. Chairman?

The CHAIRMAN. Mr. Daddario.

Mr. DADDARIO. Doctor, do I understand you correctly to say that, of the seven, when it comes to putting the first man into space, it will

be by lot and that you will not have any continuing test to determine which of these seven might be best qualified?

Dr. DRYDEN. Of course there may be people who will drop out for one reason. Maybe a man is sick on that day and therefore ruled out.

What I am trying to say is that we are not making an arbitrary selection. We hope all these pilots will get this experience in the Redstone, for example, and all will be fully qualified to go.

Mr. DADDARIO. You will eliminate as you go along if it becomes necessary within these seven?

Dr. DRYDEN. That is correct.

Mr. DADDARIO. Let me say further that looking at your standards, they seem to me to be proper and I can't think it is a proper environment for any infantry man. Being an infantry officer, I would hate to be whizzing through space at 18,000 miles an hour and try to get that thing back in if something went wrong with it.

The CHAIRMAN. Mr. Sisk.

Mr. SISK. I wanted to say this. Of course I have a great regard for these gentlemen, and realizing the tremendous responsibilities, I am inclined to disagree with my good friend from Pennsylvania. I think these gentlemen were confronted with a practical problem which make it utterly impossible to go through a long series of tests to test every individual in the United States who might have sought this examination.

We have a practical problem. We are demanding urgency, expeditious action on the part of these people. I think they have done a wonderful job here and I want to commend them on it. I just think that that would be an impractical approach, I might say to my good friend, with no criticism intended.

Dr. DRYDEN. May I say, Mr. Chairman, these men are in the process of moving to be near the project. When they have moved we plan to have them meet with you gentlemen informally so that you may learn about these men firsthand and talk with them.

Mr. FULTON. Will the gentleman from California yield?

Mr. SISK. I will be glad to yield.

Mr. FULTON. If there is any individual Army man who qualifies and applies and meets these specifications such as you have drawn up, could he have been considered, first; and secondly, can he be considered now; and thirdly, isn't it a fact that they were just really divided between the two major services, three and three, and then the minor service, the Marines, given one? The mathematical chance of hitting that is ridiculous it is like the distance between the farthest star and the earth. You just couldn't come up with that answer.

Dr. DRYDEN. About the same as drawing four aces, which happens sometimes. I assure you these were determined by numbers.

Mr. FULTON. On TV you get shot if you draw four aces too quickly.

The CHAIRMAN. Let me ask you this, Doctor. All of these men were volunteers. Just how did they volunteer?

Dr. DRYDEN. I beg your parden?

The CHAIRMAN. Just for information—and I don't subscribe to the thought that you gentlemen are doing anything other than your most serious, and I might even say grim, conscientious duty—but how did they volunteer for this program? Was it in a letter to you?

Dr. DRYDEN. No. The superintendents of the test pilot training schools recommended the 110 graduates who they thought were foremost in their classes. We began calling those people to Washington, interviewing them, telling them something about the project.

I think we called in 69 people. By the time we called in 69 people, 80 percent had volunteered to enter the program and go on with it. It seemed foolish to call the remaining men, since we wanted only something of the order of half a dozen.

The CHAIRMAN. Twenty percent, then, were not interested in your proposition?

Dr. DRYDEN. After they had heard about it, that's correct.

The CHAIRMAN. The others subscribed. Did they write you a letter?

Dr. DRYDEN. They were interviewed here in Washington. Then a selection was made of some 32, each one of whom spent some two weeks taking physical examinations; you have been reading about the types of tests that they were subjected to.

As one man said, they explored every opening in his body and they did all sorts of other physical and psychological tests.

I should say again that the medical people involved included Army, Navy, Air Force doctors. There are working in this project representatives from each of the three services on both the medical side and the technical side.

The CHAIRMAN. After you brought them in here they were not given any pressure treatment or anything of that sort to volunteer, were they?

Dr. DRYDEN. No.

The CHAIRMAN. They had an opportunity to withdraw if they wished to?

Dr. DRYDEN. That's right. We were surprised that the percentage was so high.

The CHAIRMAN. I saw over the television the wife of one of these men with several children, and they asked her how she felt. She indicated over television she thought it was a great opportunity for her husband.

Apparently all of them have really given their consent. They can still drop out if they wish to?

Dr. DRYDEN. Yes. You will have the opportunity of talking with these seven young men and you can ask them this type of question and can form your own impressions of their attitudes.

Mr. FULTON. Suppose the big day comes and the husband says yes and the wife says no? What do you do then?

Dr. DRYDEN. That man is out, of course.

Mr. FULTON. He will be out, even though he wants to go?

Dr. DRYDEN. I didn't understand your question, then. I thought you said that the man withdrew because his wife didn't want him to go.

Mr. FULTON. No. The husband still wants to go and the wife says, "No, you have three minor children."

What do you do?

Dr. DRYDEN. I don't think we will enter into the domestic squabbles.

The CHAIRMAN. Any further questions?

Mr. RIEHLMAN. Mr. Chairman, hasn't it pretty well been cleared, Dr. Dryden, that the families have agreed that they want their husband to take this chance, if it is a chance—and it certainly will be. The other point I think that should be cleared up, and has been, I believe, by the questions asked by some of my colleagues on the other side, the reason that the people from the Army were disqualified is because of the qualifications the man has to have—that is, a qualified jet pilot. We just do not have them in the Army.

At what point, when you were selecting these men, did you discover that three of them were from the Navy, three from the Air Force, and one from the Marine Corps? Do you have any idea?

Mr. LOW. On the last day. As Dr. Dryden mentioned, 32 of these men took physical examinations and stress tests. These 32 names, then, were gone over by a number of people; and I should add that the selection was a very difficult one because all of the men were so highly qualified.

Finally, then, 7 of these 32 were selected and only after they were selected did we realize which services they were from.

Mr. RIEHLMAN. I should think that—with respect to my colleague's great interest in this—that ought to clarify it, that there certainly was no chance or any possibility for anyone to make a choice between one service or the other, or to agree upon the three services being divided, two of them equally and one—which has, of course, less people in it, the Marine Corps—just getting one man.

Mr. FULTON. Would the gentleman yield?

Mr. RIEHLMAN. I certainly will.

Mr. FULTON. Did the selecting people have before them the military designation so that they knew the service at the time they were making the choice? Did they know that at the time?

Mr. LOW. They did not know the service at the time they made the choice. They had this information, but they purposely did not consult it.

Mr. FULTON. They knew it?

Mr. LOW. They did not know it as they made the choice. They did not know what number went with which name and which service.

Dr. DRYDEN. There were numbers 1 to 32.

Mr. MILLER. They selected them by number?

Dr. DRYDEN. They selected them by number.

Mr. LOW. A number was assigned when they took their physical examination. The men carried this number through with them to the final selection. The number and the name were not connected again until after the final selection had been made.

Mr. DADDARIO. What was the military representation in the final 32? How was that lined up?

Mr. LOW. It was approximately, half and half, between the Air Force and the Navy, with a few marines included.

Mr. DADDARIO. Isn't that the reason there was generally a breakdown of this same proportion all the way through, and therefore it came out pretty well in mathematical proportion and choice to the arrangement you had in the first place, as you narrowed it down.

Dr. DRYDEN. That is correct. The distribution we started with was roughly the same.

Mr. DADDARIO. Therefore it isn't unsual at all. You finally came up with this since it was balanced in that proportion to start with.

The CHAIRMAN. When there were 32, were there any Army men at all in the 32?

Dr. DRYDEN. No Army men.

Mr. FULTON. Were there any colored people who were originally recommended or asked to volunteer?

Mr. LOW. I wouldn't know if there were or not.

Mr. FULTON. On the selection of volunteers you wanted to have volunteers, did you go to the various services and say, "We want a balance as to color"? Or does everybody——

Mr. LOW. No, sir. I might add that the 110 candidates we had were almost all the available people that met all of our criteria. There may be others that also meet them, but they are now assigned in the services in jobs where they cannot be spared.

It was my understanding that we were given the names of most of the people who met these qualifications.

Mr. FULTON. Did colored people ask to volunteer and were looked over, even though they were capable?

Mr. LOW. I would not know because we never asked this question.

Mr. FULTON. Was that factor not involved in asking for the volunteers?

Mr. LOW. That factor was not at all involved. We did not ask.

Dr. DRYDEN. Any more than the marital state?

Mr. RIEHLMAN. Mr. Chairman, I think I still have the time.

The CHAIRMAN. Yes.

Mr. RIEHLMAN. Certainly there would have been no question in your mind, if there had been a colored boy in the group and he was qualified—there would have been no restriction placed upon him?

Dr. DRYDEN. We have many colored engineers in NASA—professional people.

Mr. RIEHLMAN. But in the program of selecting, you didn't ask that a colored boy be selected because he might possibly have the qualifications. I think that should be clarified.

Dr. DRYDEN. One other interesting detail. If a man showed that he was motivated by the glamor or personal glory, he was disqualified. We did not want that type of individual in this program.

Mr. FULTON. I notice you disqualified all Congressmen right away.

The CHAIRMAN. I haven't heard any protests.

Mr. FULTON. You must remember I volunteered last year, and I am protesting.

The CHAIRMAN. Let me ask you one more question, Doctor——

Mr. MILLER. Just because you are a bachelor, you are not fully qualified.

Dr. DRYDEN. I think we would be glad to have Congessman Fulton go through the same series of tests that these men went through, if he would like to do it.

The CHAIRMAN. He is a Navy man. He is disqualified.

Let me ask you a question, if I may. What about the weight? I see nothing there about the weight.

Mr. LOW. We felt all these men were in top physical condition and that their weight would not vary enough to make any difference in this mission.

The CHAIRMAN. You mean that is regulated by the requirement——

Mr. LOW. Between the height and the excellent physical condition, the weight is controlled.

The CHAIRMAN. Mr. Anfuso.

Mr. ANFUSO. Dr. Dryden, I am sure that none of the questions asked here by anyone on this committee were intended to reflect in any way upon the great job you are doing. I am sure that this committee to a man respects that.

I would like to ask you this. Would you have any objections if an award were to be given to one of these men who successfully completed such a flight?

Dr. DRYDEN. No; I think I would wait until after the event rather than at the present time.

Mr. ANFUSO. You would have on objection to seeing such an effort properly rewarded?

Dr. DRYDEN. I might be the first to recommend it.

Mr. FULTON. Monetary or——

Mr. ANFUSO. I think it should be both. One more question. There is a possibility that these seven may not be available when the time comes. Are you making any provisions for training or qualifying reserves, so to speak, Dr. Dryden?

Dr. DRYDEN. There are 25 others who have gone through the physical tests. We are not at this time entering them in any training program. If we find in 6 months that we have lost three people, I think we will start to fill the places.

Mr. ANFUSO. You have a reserve?

Dr. DRYDEN. We have a reserve of 25 who have had all the long series of physical and psychological tests.

Mr. ANFUSO. Thank you, Dr. Dryden.

The CHAIRMAN. Any further questions? If not, we thank you very much, sir.

Were you through?

Mr. LOW. I had one more chart. I can skip it.

The CHAIRMAN. No; we want to hear the rest of it.

Mr. LOW. This is our present schedule, and I would like to emphasize again that all dates here are target dates only We may, at any time in the program run into a difficulty that is now unforeseen which may delay us by a week, a month, or perhaps even several months.

But currently we are planning to use the solid rocket cluster, the Little Joe vehicle, for our development tests during the last half of calendar year 1959.

After the McDonnell capsules become available, we will then qualify these on the Redstone and Jupiter vehicles. The Atlas ballistic flights will at first also be conducted with our development capsules, the simplified vehicles I discussed.

Some of these flights will also come during the last half of calendar year 1959. Further Atlas ballistic flights will be made early in 1960.

After these prove completely successful, the first orbital missions will be undertaken with Atlas. After instrumented flights are successful, we will fly animals in satellite orbit with the Atlas; and finally, after all of those tests completely prove the reliability of the system, man will be flown in the orbital mission.

As far as the funding is concerned, we have $37.66 million in 1959. We have been authorized a supplemental for fiscal 1959 of $20.75 million, and we are asking for $70 million for fiscal year 1960.

Thank you.

The CHAIRMAN. Thank you, sir. Thank you very much.

The next one we have here is Mr. De Marquis D. Wyatt on Advanced Technology.

Mr. MITCHELL. May I say to Dr. Dryden, if Mr. Fulton does take these tests, in view of the questions today, I would suggest that you get a Democrat to go along and take those tests, too, so there won't be any problem.

STATEMENT OF DE MARQUIS D. WYATT

Mr. WYATT. Mr. Chairman, gentlemen, mine will be a fairly brief presentation. I wish to discuss with you some of the advanced technology that we are requesting funding support for in 1960.

The previous speakers have talked about some of our mission requirements, our mission objectives, some of the vehicles that we hope to procure.

In order to exploit these to the fullest in the years to come, it is necessary that we begin early study of some very basic fundamental problems that are associated with more advanced phases of flight and more advanced booster capabilities.

For example, yesterday Mr. Hyatt discussed the million-pound-rocket engine and the Nova vehicle to which we intend to apply it. As he pointed out, this is a very large vehicle having 6 million pounds of thrust from the ground comprising as many as seven stages, depending upon the flight mission.

In order to really make this kind of a vehicle, there are a number of things that we need to know that are not current state of the art. For example, you may not be able to see the size of the man here. This vehicle may run as high as 300 feet tall.

We have questions about what should be the structure of this kind of vehicle. You see, in present practice we have some practices in which the whole load is carried by the tanks themselves, the fuel propellant tanks. In other cases we have carry-through structure systems. We have a system here that weighs almost 5 million pounds. We have to learn what is the most efficient way to build this structure, keeping in mind that here is a vehicle too big to ship around the country in an assembled form.

So there is going to be a lot of assembly onsite. We have to study structural methods that are not only efficient as far as a flight article goes, but are efficient in terms of construction on the site so that we can assemble this and get it away at the least cost.

This includes not only the primary carry-through structure, but the tankage and the erection problem; and I might add the launch problem itself.

We have to study what are going to be our requirements in the way of a launch stand, in the way of propellant supply, and this sort of thing. So here is one category of what we call advanced vehicle systems that we are asking $1.5 million to initiate studies so that we can then from the studies firm up some hard facts of problem areas we want to hit and methods to proceed and then proceed in future years with the actual construction of the Nova stage.

Another factor here that came up in the discussion yesterday was relative to the cost of a vehicle such as Nova. We estimate—it is a roundhouse guess, but we estimate that Nova assembled and ready to

go may cost approximately $40 million to $50 million. Obviously you would like to reuse as much of this as you can.

This means we are very interested in learning how to make a booster-recovery system that will recover at least the engines and as much of the first-stage items that are expensive and hard to make as possible.

In fact, if possible, we would like to be able to recover some of the upper stages. So we want to start some studies to find out first off what are feasible recovery schemes, and by recovery I don't mean necessarily flying it back to the launch pad, but simply so we can fish it out of the water and reuse it with some minor rework.

How far can we look in the way of recovery? Can we hope to recover beyond the first stage? Is there any chance of recovery in the second stage? There are a number of associated problems in this booster recovery area, but we think the economics of the situation when we get into these very large-scale boosters—and in fact well below the Nova—would warrant us to spend some money learning how to recover and reuse the important components.

We are asking in the 1960 budget a sum of $1.5 million to initiate studies. These would include not only paper studies, but would go on into wind-tunnel tests of systems that look feasible to find out whether we can in fact come up with working systems involving perhaps retrorockets or parachutes or whatever.

In another phase I discussed before this committee several weeks ago some of our long-term objectives in the field of orbiting space laboratories. You may recall that we feel that there is a need in the future for a permanent space laboratory station, one in which we can conduct a number of varied types of experiments, some scientific in nature, so indicated on the left portion of this oribiting vehicle in which we might study biological, microbiological, observatory astronomy experiments; and this sort of thing.

On the right side, perhaps even more important from a practical viewpoint, a technological laboratory in which we can evaluate the materials and components that are going to be necessary for long-term space flight out to the moon and other planets.

The CHAIRMAN. Is that a manned laboratory?

Mr. WYATT. Yes, sir; this would be a manned permanent space laboratory. I have indicated here—I will recall for you—that this laboratory would be compressed. Technically it is capable of being launched by one Nova. It would weigh about 150,000 pounds, and Nova has that capacity to put 150,000 pounds into a 300-mile orbit.

This, as you may recall from my previous discussion, has a very useful volume, the volume of a small modest sized home. It could be of the order of 20 to 30 feet in diameter and 80 to 100 feet long so that we could do a lot of work in here.

The reasons, for example, in the technological field that we need this, as I pointed out before, are that when we send man off into space—and I don't mean just orbiting around the earth, but off to the moon or off to the planets—we are going to have to have the most perfect piece of mechanism man has ever built in order to assure getting him there and getting him back.

Contrary to the impressions of the cartoons in which you take off and then suddenly decide you forgot your wallet and you come back and get it, we are not going to fly space vehicles in this manner. They are going to be essentially committed.

Once they leave the ground they are committed to a flight because of the power requirements, and everything must work until we get out and accomplish a mission and come back.

This means that in the case of a flight to planets such as Mars or Venus, things must work for periods of upward of several years. We cannot afford weightwise to carry a lot of spare parts. We will carry a certain number, but we cannot afford to carry along a lot of spare gear that we throw into emergency service. Hence we are going to have to have extremely well-developed mechanisms, developed in the environment in which they have to operate.

Through a permanent laboratory of this sort, we will be able to expose technological elements to the environment of space, to radiation, to micrometeorite encounter, to the vacuum of space. We can study them over an extended period of time to prove out their reliability.

With a system such as this, in the first place we need to study how to build a system of this sort. It is a different kind of airframe, if you will, or space frame than man has ever built. We feel that it is time to begin studying the detailed problems of a space laboratory of this sort, and to begin to try to determine what are the elements of design that again are efficient and reliable. We are requesting in fiscal year 1960 the sum of $2 million to initiate studies on the peculiar problems of the orbiting space laboratories.

Mr. FULTON. Could I ask you about how it appears in space? Is it twirling like a drum major's baton?

Mr. WYATT. Yes, sir. In this particular one we would provide jets in our concept so it would be rotating about this as an axis. In other words, it would be spinning in and out of the boards in order to provide an artificial gravity.

It is perhaps not absolutely essential that we have artificial gravity. On the other hand, our concept is that for man to live in here over an extended period of time, probably the disorientation due to no gravity field would be rather severe. Hence if we spin it, we can introduce an artificial gravity.

You will note here incidentally that you can't tell which end is up. These people down here think the bottom is at this end because the center of gravity is in the center. This man over here thinks the bottom is at this end. Simply the center of gravity is in the center, then.

Mr. FULTON. People on either side of that thing are head to head with their feet out toward the outer circumference?

Mr. WYATT. That is right. Each of them is walking on the apparent bottom, which is the end in either case.

The CHAIRMAN. If they walk from one end to another, what happens?

Mr. WYATT. He would find himself going upside down at a certain point.

Mr. FULTON. They would turn a somersault at the center.

Mr. WYATT. This is a small engineering detail we haven't yet solved, just how he turns around. He would in fact, as he progressed through the center of gravity, suddenly find himself starting to be upside down. But at such a very low gravity level it probably would not be any problem.

The CHAIRMAN. He can reverse himself without being a problem?

Mr. WYATT. Yes, we think so.

Mr. FULTON. As he climbed down the ladder——

Mr. WYATT. He would find he was walking on his hands if he goes too far.

Mr. FULTON. How does he change? What does he hold on to to make the change?

Mr. WYATT. I must confess that is a detail we have not yet solved. We don't think that is going to be insurmountable.

Mr. FULTON. Because he would at that point have no gravity at all and he would be floating.

Mr. WYATT. Seriously, sir, what we may provide here is, rather than a ladder, some sort of a dolly. As you know, in the B–36's, to go from the rear section up to the cabins, they wheel themselves through a tube on a dolly. It is quite possible we would provide some sort of mechanism of this sort and he could spin on the dolly when he got halfway through and always be going the right way.

Mr. FULTON. And as he climbed through the doors to the center he would find that coming down from 150 pounds, he would be down to where he weighed 25 pounds.

Mr. WYATT. He would have a variable gravity as he went from a lower level to an upper level, so to speak.

Mr. FULTON. If he took a jump at 25 pounds, he could probably take a jump maybe 15 feet high, couldn't he?

Mr. WYATT. All of 15 feet, I would suspect. I haven't figured these out, but the gravity would be zero here and we might pull it as high as 1G. We probably wouldn't have to go to 1G. We would go to a quarter of a G gravity out here, enough so a man is oriented rather than disoriented.

Mr. FULTON. So you couldn't have any living compartments near the center because you couldn't have any gravity, and they wouldn't rest on tables.

Mr. WYATT. We visualize the living compartments would of course be at the ends.

Mr. FULTON. How many times a minute would that spin?

Mr. WYATT. I don't recall that calculation. We made such a calculation. It is not too rapid a rate of spin.

Mr. FULTON. Would anybody get dizzy?

Mr. WYATT. No, sir, but that is the reason we have indicated here schematically that this could separate into two parts in order to cut down the motion, the spinning effect. In other words, by lengthening this out as far as possible you could spin it as slow as possible in order to build up your level of gravity.

Actually this is a field about which we know not too much. That is, we know that there is this so-called coreilis effect that sets up in a man due to spinning. We also have some indication in the flights that have been made to date upward of a minute that some people are disoriented, discombobulated one might say, and others are not by the weightless condition.

We need to find out, and we will through such experiments as Project Mercury, what is a man's real tolerance to weightlessness and how necessary is it that we have an apparent weight and hence we are not ready to design this final thing yet.

We want to proceed along the orderly line. This would not be the next generation of space vehicles. This would be several generations down the road. But these are the sorts of problems that need to be studied to build up this information upon which to design it.

Mr. FULTON. In order for a man to be the same weight at every place in the same floor, wouldn't the floors have to be curved into a slight arc and you have them straight?

Mr. WYATT. Yes, sir. To have absolutely the same weight, that would be correct. But in practice, with a dimension of 50 feet, it would be so slight I don't think a person would notice it.

At any rate, we have this problem of how to build this and we then have another problem that comes up. That is, if this is to be in space permanently, we must then reman it and resupply it from time to time.

We would visualize that we would do this by other supply ships that would come up. We show up here a possible method of connecting our supply ship in from the nose where we would perhaps shoot out a magnet on the end of a rope, hook on to the supply ship when it got close, and then pull it in to make contact.

This means we have to be able to get in the immediate vicinity of the orbiting space laboratory. This brings in what we call a space rendezvous problem—the problem of getting into contact or near contact with a body already orbiting through space.

It is not simple. It requires a high degree of knowledge on the one hand of the body you are trying to rendezvous with, what its exact path is, and a very high degree of guidance in order to get you into the exact path.

It means that you have to carry along auxiliary power that you use for the purposes of course correction. We want to study all of these things. We want to study the power requirements; we want to study the kinds of power sources, whether we should rely on electrical jets of very low thrust, but applied over a period of time; whether we rely on stored gas jets; or whether we rely on actual liquid rockets of some sort.

We want to know how to stabilize these things, and of course I mentioned the guidance so that we can make accurate contact.

These are areas in the so-called space rendezvous problem which we believe need to be studied immediately so that we can begin to build in the years to come the kinds of vehicles that will be required for rendezvous purposes where we want to bring things together.

In the budget this is under the heading of Space Operations Technology. We are asking for the sum of $3 million next year for the study of space rendezvous techniques and for construction of certain of the basic mechanisms required for stabilization and guidance of these sorts of vehicles.

But these sums of moneys I have been discussing are all moneys required to initiate the basic studies so we can have a firm foundation for later exploitation of a field. We have benefited greatly in the past from the studies that have been run, and we feel that these sorts of studies need to be extended now to these new areas.

Thank you.

The CHAIRMAN. Thank you very much, sir. Members of the committee, that completes the section——

Mr. FULTON. I would like to ask a question. On the type of orbiting vehicles we have now, of course they are ellipses and they therefore are going slower around their apogee; and when they come into the perigee they are moving very much faster. So they are accelerating tremendously and decelerating.

Wouldn't it be necessary then to almost have a circular orbit with a constant speed before you can talk about getting together things going about 17,000 to 20,000 miles an hour?

Mr. WYATT. Yes, sir. This is one of the first problems—to be able to guide accurately into a circular orbit so that you can establish—the thing you want to rendezvous with should be in as near a circular orbit as is possible.

Mr. FULTON. If you were going to rendezvous with another orbiting vehicle and found you made a mistake, you wouldn't have to worry very much.

Mr. WYATT. No, sir, nobody would have to worry.

Mr. FULTON. If you hit something going 17,000 miles an hour, you would smash.

Mr. WYATT. It would all become an academic problem.

The CHAIRMAN. Thank you very much. Members of the committee, that completes the section on programs. We have finished the first section here, and the one on program.

Next is the one on facilities. It is 4 o'clock this afternoon. It occurs to me that we had better adjourn until tomorrow morning to take this up. I want to suggest this, and want to make an appeal to the members to get here on time.

What is before the committee now is as perhaps as complete a program as I have ever seen given to a committee by NASA. I want to tell Dr. Dryden now I think your people are doing a superb job in presenting this to the committee. I hope that as many members of the committee as possible can be here for the rest of this.

Tomorrow we will take up facilities, and we have Mr. John W. Townsend, Jr., of Beltsville; Edmund C. Buckley on tracking, Pacific Missile Range; and Donald Heaton on propulsion facilities.

Then we have under section IV, aeronautical and space research, Ira H. Abbott on the introduction of program and facilities; then we have another section on program, which is headed by John P. Campbell, vertical takeoff and landing aircraft; Herbert A. Wilson on the subject of aircraft—supersonic and hypersonic. We have Mr. Rodger A. Anderson on structures for hypersonic vehicles; Mr. Hubert M. Drake on piloting and control problems—X–15 project. We have Mr. Milton B. Ames, Jr., on the subject of missiles.

Then we have finally facilities, with Mr. Ira H. Abbott on the subject of construction and equipment. Then we have salaries and expenses, and we conclude with a statement by Dr. Hugh L. Dryden, and we will close the entire briefing.

That gives us a pretty heavy week's work. It is my thought that we might be able to finish by Thursday night and give the committee a recess Friday and Saturday. If we can, fine; if we can't, that is another thing.

If there is no objection, then, it is now 4 o'clock and the committee will recess until tomorrow morning at 10 o'clock.

(Whereupon, at 4 p.m., the committee recessed, to reconvene Wednesday morning, 10 a.m., April 22, 1959.)

1960 NASA AUTHORIZATION

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
Washington, D. C., Wednesday, April 22, 1959.

The committee met, pursuant to recess, at 10:10 a.m., in room B-214, New House Office Building, Hon. Overton Brooks, chairman, presiding.

Mr. MILLER (temporarily presiding). The committee will be in order. Unfortunately Mr. Brooks will be delayed for a few minutes and has asked me to take over. We will deal with facilities this morning. The first witness will be Mr. Edmund C. Buckley, tracking, Pacific Missile Range.

Mr. Buckley.

STATEMENT OF EDMUND C. BUCKLEY

Mr. BUCKLEY. Mr. Chairman and gentlemen; the area which I would like to discuss has the general title of "Tracking Facilities and Data Acquisition Equipment."

This is the equipment that provides the information to the experimenters that you have been hearing from during the previous part of the program. These experimenters have described certain scientific objectives and certain experiments, and they expect from these experiments certain data to be provided to them which they then can analyze, study, and write scientific reports.

These data that will be made available to them will be the payoff, then on the flights. The whole gist of the experiment will be the data which they receive. They describe various measurements they want to make in the course of these flights. In the main such data have to come to the ground, of course, by radio signals.

These data have to be transmitted and received with as great an accuracy and quality as possible in order that the information is carried back to the experimenter without any loss.

It is not enough for the experimenter to know only the measurements of the temperature and what radiation and so forth is up there at this point in space in this vehicle. He has to know the exact point in space where this measurement was made. So if he measures a certain radiation and he knows where the measurement was made, he can define the radiation belt or whatever it is. It has to be defined in space. A position in space has to be assured him as well as the exact measurement.

On the ground then, there is a network of facilities that collects this data and also makes measurements of where the satellite or the space probe is. As the NASA took over, there was a certain group of such facilities existing that were put up for the International Geophysical Year, which is just finishing up now in the next few months. As the

NASA took over, there were certain changes that were obvious. There were changes in requirements. There were orbits that were going to be used that had not been planned during the Geophysical Year. There were objects that were going to be fired off of the earth toward the moon or beyond. There were changes in state of the art of making such measurements on the ground.

So our plans then are to look at the network, the systems that were provided for the International Geophysical Year, and consider what improvements and augmentation is necessary for these new jobs, the newer requirements, and also to improve the state of the art because this art of making these measurements is a very new one.

As the NASA started on this last fall, it was obvious that there were two sets of requirements, one for the NASA and one for the military. They have their requirements, too, stemming from their defense mission. First a study was made by a joint group from the Department of Defense and the NASA which ended up in agreement on January 10 by Dr. Glennan and Mr. McElroy that defined, as far as we could as of that date, the missions of the two groups, showed where they merged and interlocked, assigned responsibilities in different areas of this tracking work to the NASA and to the military.

Our mission, of course, is the civilian and scientific purposes and to a certain extent the data has to interchange between these two units. To a certain extent they can be isolated.

Mr. MILLER. Are they fully coordinated?

Mr. BUCKLEY. We hope they are, sir, yes, sir.

Mr. MILLER. There is no overlapping or duplication of effort on anyone's part?

Mr. BUCKLEY. We are endeavoring to keep it to a minimum. This agreement which was signed January 10 envisioned the formation of a continuing committee between the Department of Defense and NASA. This has been set up and it has had only one meeting, but it has been created and the people have been designated—three from the NASA and three from the Department of Defense.

Dr. DRYDEN. May I mention that copies of this agreement have been furnished the committee before.

Mr. BUCKLEY. Picking up the actual facilities themselves, the facilities that existed as of last June were of two types. There was an optical network wherein pictures of this body way out in space were taken against a background of stars by a very special camera. This ended up in a photographic plate showing the stars and showing the satellite against it, and this gave extremely accurate data to one in four one-hundredths of a degree in space as to where this was.

There were a number of such stations and they are placed around the world in various places like this. In placing them they are always between the 30 degree north and 30 degree south latitude because at the time they were put up, the firings from Canaveral for the International Geophysical Year were all envisioned to have a track that stayed within this 30 degrees north and 30 degrees south.

These stations which were so accurate had a couple of limitations. One is that they had to have clear seeing, and the other one is that they could only photograph for a couple of hours before the sun came up in the morning, just before that, and a couple of hours just after the sun went down.

Mr. ANFUSO. Mr. Chairman, may I ask a question there? Would you please mention the countries where those stations are?

Mr. BUCKLEY. Yes, sir. Japan, Australia, Hawaii, United States—I am going to skip one here for a minute. I will be back to it—Curacao, Ecuador, Argentina, Spain, South Africa, Iran, and India. There was a station in Havana, Cuba, and starting approximately the first of November we began to make negotiations for moving it, and the station is now erected in Fort Myers, Fla.

Mr. ANFUSO. You are discontinuing that station in Cuba?

Mr. BUCKLEY. Yes, sir.

Mr. ANFUSO. You are finding a more secure place for it?

Mr. BUCKLEY. It is a lot easier to operate, yes, sir.

Mr. ANFUSO. You are not afraid of Castro's regime?

Mr. BUCKLEY. We got along pretty good actually there. You had to be careful what color your vehicles were painted and a few things like that which make it a lot easier to operate in Florida.

Mr. ANFUSO. You have to be afraid of the color of some of the people running the government, too.

Mr. BUCKLEY. To supplement the optical network there was an electronic network, which, due to an antenna array—you have seen these antennas with all sorts of pipes and tubes and things. They in general direct a beam or receive in a particular direction. There was a network composed of 10 stations with these very special antenna arrays. These are the sort of things—they are a few hundred feet long, each of them. They in general receive a signal from only a very small point in space.

The accuracy of these is only about one-fourth or one-fifth as good as the optical group, but they are not limited to the seeing conditions and are not limited to the time of day.

The location of these stations are where the red spots were here. Excuse me, sir, I want to correct one thing. It was the electronic station that was in Havana.

Australia, two in the United States, and Havana, which has now been moved. Quito, Ecuador; Lima, Peru; two in Chile; one in South Africa.

Again these stations were placed between 30° north and 30° south. This track that is on here is for a 51° orbit and not for a 30° orbit.

Then starting last October, roughly, we began to think about what to do to catch up with the problem that was ahead of us. We were firing from Cape Canaveral on a 51° north orbit which gave a wider swing and these stations were not quite good enough quality for this. So this was one requirement. The other thing was that we were going to be shooting from the Pacific Missile Range on a polar orbit which goes around the earth north and south. This orbit would be represented by these vertical black tracks that you see here.

Finally, as a definite aid to the specific type of operation of a 51° orbit, we tried to put stations along its course so that very quickly at the end of its first trip around—before its first trip or at the end of its first trip—it could be clearly established that it was in orbit.

Previously when we fired south, the station at San Diego provided this check, supplemented by the one in South Africa. So balancing these factors, we planned a station in southwestern Europe. At the moment it is being planned for Spain because this is being coordinated

with a Department of Defense requirement. A station in Newfoundland, one in central United States over which the first pass of the vehicle will go, the end of the first pass, and one in Alaska specifically because of the polar requirement, but all of these have been planned to have good polar coverage. They are spread out this way. The original IGY was strongly up and down here, and these additional four stations are spread out in this direction.

Mr. ANFUSO. One more question, Mr. Chairman. On the Pacific side I only see a station in Australia. Are you contemplating one in the Hawaiian Islands or some other place in that direction?

Mr. BUCKLEY. Not in this network sir. Actually now, the stations of this type sample the data. They get a sighting today and two sightings tomorrow and perhaps two sightings the next day. If you have stations that can pick up the orbit during the first few passes, as well as you can, and then make a reasonable distribution around the earth to get the sample data, this is a good combination of ways to do it.

The other factor on placing these stations naturally is that we have been trying to place them where it was politically good sense, the logistics and the politics made good sense. That is one factor that has affected where they have been placed.

Mr. FULTON. Is that in Montana too?

Mr. BUCKLEY. No, sir, we didn't give any thought to that here. This is North Dakota at the moment.

Mr. FULTON. Had you had any correlation with equatorial satellite programs? You didn't mention that.

Mr. BUCKLEY. No, sir. These stations, some of them would be useful around the equatorial orbit but there is no definite requirement for an equatorial orbit firing as of yet. It is under discussion by the scientific people.

Mr. FULTON. That is not my point as to whether it is required now. I said did you correlate the placing of these stations on this type of orbit with an equatorial system that is in view? Has that correlation been given thought?

Mr. BUCKLEY. It has been kept in mind, but there were no station locations that were fixed because of thinking about that. The balancing of the factors and the importance of putting it in for the reasons I gave, and the future requirement of the equatorial range, meant the funds would have to be spent for the stations I have designated here. That was kept in mind. It was a balance of the requirements.

Mr. FULTON. On the pattern of these orbits, possibly had they been moved slightly to the west you would have then had a water sight for a station which I have suggested at the first point of Aries. Or if you were using the present pattern that you have there in that same configuration you could still, for this particular type of orbit, use Christmas Island, couldn't you?

Mr. BUCKLEY. Yes, sir. These South Pacific islands are being looked at more specifically by Pacific Missile Range, who have been assigned the area in here. They have been given a general assignment to consider the tracking problems in the Pacific missile area.

Mr. FULTON. I have been interested in having Christmas Island used for an equatorial station on an equatorial program of satellites. So

my question then was, have you correlated with the people working on the equatorial program satellite the placing of your stations, because I could see an overlap there in the Pacific on the courses you already have laid out for your type of orbit.

Dr. DRYDEN. Perhaps, Mr. Fulton, I might try to answer that. The subject of an equatorial launching site is under active consideration. There is at present in the program no firing which requires an equatorial orbit from an equatorial launching site. It is possible to put a satellite in an equatorial orbit, firing it from Canaveral when we have the payload capacity to put on the additional rocket propulsion needed to switch the orbit plane.

As a matter of fact, I believe in the communications satellite presentation there was a description of the method by which firing from Canaveral, then going to a transfer elipse to get to the 22,000 miles, you then applied an impulse which switched the orbit plane to the equatorial plane. Some studies have been made of the cost of an equatorial launching range. It is of the order of $300 million.

Studies have also been made of the possibility of using a ship launching station, a mobile launching station. You have a problem in economics of how many equatorial firings are you going to have, what is the cost of doing it from a ship, what is the cost of doing it by launching from Canaveral and putting in the payload, the rockets necessary to change the orbit plane. All of these factors have to be weighed.

At present there is not in the program a fixed requirement for firing from an equatorial position. Studies have been made in the area you have mentioned. Christmas Island is one of those most prominently mentioned. There have been estimates of the cost of construction. At the present time we have a group trying to lay down the requirements for scientific purposes and military purposes of an equatorial launching site.

Mr. MILLER. Mr. Buckley has told us how they tried to coordinate the military with NASA in the establishment of this system. Am I right in assuming that in this agreement you who are concerned at the present time with the pure science and the military who have a very practical approach to the problem, that perhaps in your conversations with them they helped to coordinate as to where these tracking ranges will be at this time so that they can bring their missiles into play along with the probe for pure science?

Dr. DRYDEN. The military have two requirements, I think you easily understand. One is the national defense; one to distinguish a satellite from a ballistic missile coming towards you. This requires knowledge at all times of what is in the sky and where they are. They also have a requirement for research and development in connection with Discoverer, for example, the development of military satellites.

As a matter of fact, at the present time this minitrack network is the only worldwide network that is in operation, built during the IGY.

As you will see from the rest of Mr. Buckley's presentation, this is solely for tracking scientific earth satellites. The information from it will, of course, be passed to the Defense Center so that they have this information, all the information that we have. We are dealing with satellites in which we put a radio transmitter for tracking pur-

poses. Military has also to have the capability of seeing satellites that are not cooperative, as we call it, those which are dark. There is a military installation across the Southern United States, a so-called dark satellite fence, for picking up satellites which do not radiate to help you find them.

So there are somewhat different requirements. They are coordinated. This agreement to which you refer specifically referred to specific agreements in 1959 and 1960 and set up a continuing committee to keep complete coordination of the tracking efforts.

We coordinate our firings. We know when each other fires. We agree on what stations are going to look at which object. I have repeated many times the statement that one of these tracking stations can only look at one thing at a time. If you think before you get through that there are a large number of them, I ask you to remember the firing schedules which show a number of satellites per month, and remember that one station, or at least one equipment on one station, can only look one place at a time.

So it does take a number of stations to meet all the military and the civilian requirements.

Mr. FULTON. Will the gentleman yield, Mr. Miller?

Mr. MILLER. Yes.

Mr. FULTON. The question would arise then along this line of questioning, as the gentleman from California has brought up: Has any consideration been given to the possible use of these peacetime scientific stations for military purposes in times of emergency? For example, I could see that if these two stations around the United States area were moved up, for example, into northern Canada and southern Greenland, you would then in times of emergency possibly use them for defense or scanning purposes or for reconnaisance purposes.

Dr. DRYDEN. Mr. Fulton, these will only pick up satellites which politely have 108 megacycle transmitters on them. I don't believe the enemy objects are going to have this. These will not of themselves pick up a satellite which does not have a transmitter. They have only receivers. This is receiving equipment on the ground to receive that transmission. It takes a different type of equipment to pick up a dark satellite. There is such an installation in the military.

Mr. MILLER. You state that for the military, then.

Mr. FULTON. I am distinguishing between instrumentation and ground installation, you see, because of course it takes a lot of support and small instrumentation. So when you were establishing ground stations I was asking if it had been correlated with the military so there is no overlapping on ground installations?

Dr. DRYDEN. It has. The agreement which refers more particularly to the next network for space probes that Mr. Buckley will describe, the agreement is that we occupy the same site, use common logistics, we share the same communications system.

Mr. MILLER. Mr. Buckley, before you got here, had brought out the fact that there was coordination. One of the first questions I asked him was whether there was any overlapping and we were told there was a minimum. There has to be some. You can't have pure coordination, but that any overlapping is at a minimum and the co-

ordination and the cooperation between the two agencies is well thought out and worked out successfully.

Mr. BUCKLEY. We are using this network for providing data on military firings that were specifically requested, where they put the 2-pound transmitter in that is necessary to cooperate with these stations, and there are a certain number of these schedules that have had requests coming to us. In fact, we call them up to be sure if, on each one, we can offer service.

The CHAIRMAN. Mr. Buckley, may I ask you a question or two. I got in late so if you have covered it, just say so. How many people do we use in this setup throughout the world?

Mr. BUCKLEY. On the camera stations, there are five at each station.

The CHAIRMAN. How many stations is that?

Mr. BUCKLEY. There are 12.

Mr. MILLER. I suggest, Mr. Buckley, that you show that chart with the camera on it and the camera stations so that the chairman and Mr. Fulton can see it.

The CHAIRMAN. Let's not go over what we have already covered there. I can read the transcript.

Mr. BUCKLEY. I have two comments on the people at these stations. First of all, at these stations when they are tracking an object, they have to get these photographs before sunrise and to get up to get the station ready, they have to be up 2 or 3 hours before that.

On the same day that they can get it, they also have to get it after sunset and it takes 4 hours of processing after that. So if we try to run it with two people—the IGY people did for awhile because their money was a little scarce, but we have increased it to five—you can see the long hours and you will see this is a necessary thing.

On these stations and on the minitrack stations we have a policy of converting to using national help—the people of the country where the station is. There are a certain number of scientific groups there that are anxious to cooperate. This seems to be a policy that helps us get along.

This does not mean a full conversion. It means that we will use them to a certain extent. We will set down certain policies as to how far we go with this thing. We will always have at least a United States citizen for a station manager at each one.

To answer your other question about how many people on these stations, there are 12 to 14 because of the more complex electronic equipment compared with the simple equipment on the camera.

Mr. MILLER. I wish you would bring out, Mr. Buckley, the efficiency of this photographic station, I think you said was one four-hundredths of a degree.

Mr. BUCKLEY. Yes, sir.

Mr. MILLER. When you can get it and there is no cloud effect.

Mr. BUCKLEY. Yes, sir; it is very accurate.

The CHAIRMAN. How many do you have with 12 to 14?

Mr. QUIGLEY. How many minitrack stations?

Mr. BUCKLEY. Ten stations, with 12 to 14 people each.

The CHAIRMAN. Any further questions?

Mr. ANFUSO. Mr. Chairman.

The CHAIRMAN. Mr. Anfuso.

Mr. ANFUSO. Dr. Dryden, you said that these stations can only watch one thing at a time; is that correct?

Dr. DRYDEN. That is correct.

Mr. ANFUSO. One satellite at a time. So the more satellites that are put up in orbit, the more stations we will need throughout the world; is that correct?

Dr. DRYDEN. Or you will adopt the policy of not looking at all of them all the time. You will have do sampling. The expansion that would take place as we see it would be mainly in additional equipment on the same site. This is not so much true here, I think, as in the space business.

Mr. ANFUSO. That is all I had, Mr. Chairman.

The CHAIRMAN. Any further questions?

Mr. Quigley?

Mr. QUIGLEY. Has any thought been given to the possibility of putting this equipment on ships?

Mr. BUCKLEY. Yes, sir. The two types of equipment I have mentioned so far, though, find out where this body is by the angle to it, the very exact angle. The problem of putting this on a ship and holding it to these angles is a pretty expensive one. You can make stabilized platforms and they are expensive even if you hold them to the quality with which you can radar. But the quality of both of these systems is far higher than that. This thing would be very difficult. You could do it, but it would be expensive.

There are other tracking systems under study which might lend themselves to shipboard use more easily. These haven't been proved at all yet. There are other methods of electronic tracking. A number of groups are attempting to make measurements and work up the data. So far this hasn't quite panned out good enough.

Mr. QUIGLEY. It just seemed to me if it were scientifically feasible it would be economically a lot cheaper. You could take it out to the Pacific if you needed it this month and you could put it in the South Atlantic next month if that is where you needed it.

Mr. BUCKLEY. The system that they are experimenting with, the equipment would be reasonably simple. But it hasn't been proven as yet.

Mr. FULTON. Will the gentleman yield?

Mr. QUIGLEY. Yes.

Mr. FULTON. I believe they are already doing it on the *American Mariner*, aren't they, just what the gentleman from Pennsylvania, Mr. Quigley, recommends?

Mr. BUCKLEY. Yes, sir.

Mr. FULTON. Would you tell us the difference between that type of equipment and what you are talking of here? The gentleman does have a good point and I understand it is about to go into operation.

Mr. BUCKLEY. It is in use and it is an excellent installation.

Mr. FULTON. Why can it be done there and not as the gentleman, Mr. Quigley, suggests?

Mr. BUCKLEY. I said the quality we are after here is some higher than we would go after by installating radar on the ships. On the other hand, you need both, especially if you are using a ship in a recovery area to watch nose cones come in. You wouldn't have to be

getting the exact data as long as it has a fair quality, you know where to go looking for the nose cone.

Some of the data that is required by our scientific group such as the people that plan the geodetic satellite which will end up giving information about the shape of the earth, or end up in establishing the position of certain islands better than ever before, needs the very best accuracy you can get, and the optical system is the only one that will do that.

Both of these systems shoot for higher accuracy than the *American Mariner*. On the other hand, the *American Mariner* and two ships similar to it are going to have a part in this whole program.

The CHAIRMAN. What is the crew of the *American Mariner?* How many people do they use?

Mr. BUCKLEY. I could give you a guess. It isn't too bad; I think about 100 to 120.

The CHAIRMAN. Any further questions?

Mr. FULTON. On the pattern there, I have a question. Why was it in each case in the Southern Hemisphere the patterns or the configuration of the orbital paths so that they fall just east, maybe 300 to 500 miles east, of the stations in Australia and South Africa?

It was originally set up for the Geophysical Year. Why wasn't it just moved over west a little so that you would find that those two stations were within the paths?

Mr. BUCKLEY. These stations were put in for the southeast firing from Cape Canaveral, a 30-degree orbit. Then they wanted to fire at a higher angle orbit, if possible, from Cape Canaveral. They could fire at a higher angle by firing northeast than southeast.

The first pass comes here, and the second here, and the third and the fourth ones would be down here, with a sampling technique. What you have sacrificed is the ability to get this orbit established on the first or second pass as well as you could with the original stations.

On the other hand, by the time the third and fourth have come along, this station is active; and by the time the fourth has come along this station is active.

Mr. FULTON. Australia, too?

Dr. DRYDEN. This is only one orbit. The stations have to be good for all the firings.

Mr. BUCKLEY. Actually this type of station, if at all possible, you get some confirmation that it is in orbit on the first or second pass. But then to really get the accurate data, it is getting data over the next several days or even weeks, collecting this, and putting it into a rather refined computing process, which then comes up and establishes this orbit with all its little perturbations in it due to the shape of the earth and the changes in the atmosphere and various other things.

Mr. FULTON. So that really the stations on the chain there, the mountains in South America as well as in the Dominican Republic, are all then able to be used for the tracking of this kind on the high-inclination orbits. Is that not right?

Mr. BUCKLEY. Yes. They are useful in all orbits. They are useful in the high-inclination orbits as well as the low. The way the antennas were laid out, these stations lose sensitivity as you go around to a higher orbit because they are put on for a low inclination; and the

way this beam was designed in the antenna system there, they lose accuracy when you get to the higher inclinations and the polar orbits.

That was the thing I was going to mention just a little bit later—that there are modifications being made on these existing stations to improve their quality on these high-angle orbits and on the polar orbits. They won't be as good as the stations that you definitely put in for this purpose, but we will improve their capability for polar orbits.

Mr. FULTON. What would be the possible use, then, of the station in Alaska when it is obviously at a much higher latitude than any of the proposed patterns of these high-inclination orbits?

Mr. BUCKLEY. If you shoot south, the highest inclination would be of course a polar orbit, 90 degrees. The only place you can shoot this at the moment, considering the safety of the boosters and so forth and not wanting them to drop on land masses here, is to fire south from the Pacific Missile Range.

This first pass is back here, and then it comes back by the Alaskan station, which is the confirmation that you so desire at the end of its first pass.

The second one comes by this South African station here.

Mr. FULTON. But it is for the polar orbit.

Mr. BUCKLEY. Yes, sir.

Mr. FULTON. Rather than the high-inclination orbit you are speaking of here in this program.

Mr. BUCKLEY. Yes, sir. It is a matter of degree, as you go up higher and higher; yes, sir.

Mr. FULTON. If the pattern of this program, then, is going to be pretty much that, at what latitude will your top inclination be? You have shown that it is just above the order of the Great Lakes, but how high will you be going?

Mr. BUCKLEY. The scientific people will want to cover the whole earth with investigations. As they started into these scientific programs, any information obtained by getting satellites up and getting some information and finding out that such peculiar phenomena as the radiation belt existed at all was an objective.

Mr. FULTON. Why do you have them also bunched right in the one particular latitude in the Northern Hemisphere if you are going to do that? Why, if it is going to be an overall pattern in the whole earth, do you bunch all your stations in about 6,000 miles and within 15 degrees of latitude?

Mr. BUCKLEY. The main answer to that is you try to put them where they are on good logistics and where it is politically expedient to put them.

Mr. FULTON. That is why I said you include Montana in that.

Mr. QUIGLEY. South Dakota.

Mr. FULTON. Is that better than Pennsylvania? That is all, thank you.

Mr. DADDARIO. Mr. Chairman.

The CHAIRMAN. Mr. Daddario.

Mr. DADDARIO. Mr. Buckley, we have had some discussion here that there might be a substitution of some television type of equipment for these cameras. What is your thought about that? As I recall the

testimony, it was that the television type of equipment might be more sensitive and it could do the job much quicker.

Mr. BUCKLEY. There are at least three proposals in the country where they will replace the plates in the back of the camera with television equipment. This apparatus is far more complex, of course, electronically and so forth than a basic photographic tried-and-true technique, which is a duplicate of what the astronomers have been using for years. At the moment I would say that this is far from proven.

I assume you mean now the television used on the ground. Of course this television equipment that is going to be proposed in the satellites themselves——

Mr. DADDARIO. I am talking about just for this particular purpose, a substitution for the plates and so forth.

Mr. BUCKLEY. My answer is that there are three different groups working on it that I know of, and it is quite a way from being proven yet.

Mr. DADDARIO. But it does have good possibilities?

Mr. BUCKLEY. That's right, yes, sir.

Mr. DADDARIO. Are you satisfied that there is enough work being done on it so that we can determine whether or not it can do this job and whether or not it can do it better?

Mr. BUCKLEY. I think so. There is a pretty active group investigating this that visit with one another and so forth. This will probably be part of the subject of this DOD-NASA Committee that we have discussed earlier, as to the future possibilities to both the Department of Defense and ourselves. At the moment this is being investigated individually by both ourselves and the Department of Defense, and they have called us over to their meetings on the subject, for instance.

We have had the astronomers down to discuss this. That is about the state of it at the moment.

The CHAIRMAN. Had you finished your statement, Mr. Buckley?

Mr. BUCKLEY. What I have talked about so far is for bodies that go around the earth in a satellite. They stay in an orbit around the earth. When these vehicles leave the earth and go off toward the moon and beyond, you have the problem of getting these extraordinary faint, very, very faint signals, receiving these very, very faint signals, from these vehicles.

This requires equipment that is far better for receiving faint signals than anything that has ever been built of this nature before.

The equipment starts with a great big parabolic dish or reflector here. This particular one is at Goldstone, Calif. It is 85 feet in diameter and part of the equipment is very, very special electronic equipment, the latest state of the art such as parametric amplifiers and maser amplifiers and so forth, that constitute the very latest in electronic equipment that can receive these signals without generating any internal noise in the electronics itself.

In addition this dish by positioning itself on these signals gives us this direction to the body that is up there. Finally, this dish, of course, is receiving this telemetering data from this. It gives us the information up there which the scientist wants to know of the measurements he is making.

This dish, this particular one, combined with two adaptations—an adaptation of the Goldstone radar in Massachusetts and an adaptation of a radio astronomical telescope in England—was the setup that was used to track the Pioneer IV. These two pieces of equipment, the radar in Massachusetts and the radio astronomy dish in England, were built for other purposes. They were doing research in other fields, and to adapt them to this required quite a bit of change.

Some of these vehicles that go off into space would need such equipment assigned to them for 200 or 300 days. In other words, you would ask the radio astronomer in England to take his equipment off the line as a radio telescope and assign it to you for 200 days.

What we intend to do here is to add a station in South Africa and a station in Australia similar to the one you just saw, making a network of three stations.

The CHAIRMAN. Those will be new stations, now? You don't show them on your chart.

Mr. BUCKLEY. Yes, sir. These charts here were for the optical network and this electronic array network, and they were for satellites. This is for the vehicles that go out in the deep space probes.

If the vehicle gets about an earth's diameter away, one or the other of these stations can see it all the time. So if you have three stations separated by 120 degrees, approximately, and near the Equator, one or the other of these can see them.

For a satellite, you get over the curve of the earth and you can't see it; but with a vehicle that goes out far enough, one or the other of these three stations will see it. So the program then is to add two stations to the one in Goldstone.

The third area of this tracking that I want to mention is the specific one for Project Mercury. Project Mercury is only going to be up for two or three orbits. That is 3 hours or 4½ hours. The other satellite stations obtained their data because as the earth rotated, you were able to get sightings today, tomorrow and the next day.

But Mercury is only going to be up 3 hours. The stations will have to be right on the plane of that orbit because they are not going to rotate into view.

In choosing the orbit for Project Mercury, three things are kept in mind: Where you launch in order to use existing equipment as far as possible, because it is very important that this be put into orbit and confirmed that it is in orbit. Secondly, how to make the measurements as to what orbit. Thirdly, where to land the man—again bringing him, if at all possible, into an extremely highly instrumented area so that you can assure yourself that you will pick him up just as quickly as possible.

So the orbit that was planned was to fire from Cape Canaveral using the normal Cape Canaveral launch facilities and all the tracking equipment on launch; over Bermuda; and at the end of the first pass he come in about here; and at the end of the second pass over Hawaii, across the southern United States where there is quite a band of existing military stations that we expect to use, and into the Cape Canaveral area for recovery, using the Cape Canaveral equipment with all their tracking equipment to be sure you are on him just as quickly as possible and can vector in the Navy's ships to pick him up quickly.

The first critical condition from the tracking man's point of view is shortly after he is in orbit, which is halfway to Bermuda, you would like to be sure that he is definitely in orbit because if he is not, you can't tell where he is going to land very easily. He could be quite a ways around where he would be very difficult to find.

So we would like at Bermuda to measure his trajectory and be sure it is in an orbit that will keep on going around. If it isn't, we would like to fire the retrorockets at Bermuda and bring him out where there are ships that will be placed in the Atlantic Ocean.

In other words, fire these retrorockets at a particular point that will bring him where there are recovery forces ready to pick him up.

So the function of a station in Bermuda would be a very critical one to make this measurement—the first pass; and if he isn't in the correct orbit, to knock him out of the orbit at a particular time so he gets down to where the ships are.

The CHAIRMAN. Who is going to fire the retrorockets there? Will it be done from the ground or from the ship?

Mr. BUCKLEY. It will be done from the ground, sir. On the other hand, of course there is a backup. We will be talking with the pilot and the pilot has the ability to fire them too if need be. But the intention is to fire them from the ground.

Associated with this Bermuda station then would have to be a pretty good quality computer to do this job of verifying this orbit in this one sitting. This is a job that is beyond the work that has been done in these other forms of measurements here.

We intend to put a station in Hawaii making use of whatever is there, in addition, but if this orbit is relatively low, if the stations that are there cannot see this orbit because of where it is, relative to the station, if he is down below the horizon, I am afraid we will have to put a station in Hawaii similar to the one in Bermuda, and again with a computer.

The purpose of this is much like the one in Bermuda in that the station in Hawaii will verify his orbit, again compute where this retrorocket should be fired so that he will land on the Atlantic Missile Range, down at Cape Canaveral. So that the tracking equipment here and the computer will fire the retrorocket somewhere before the coast of California is reached.

Then as the vehicle comes in we will use the facilities of Pacific Missile Range and White Sands and Eglin, and finally Cape Canaveral to track him down this very important route so that we know exactly where to send somebody in to get him picked up in the few hours which is allowed for picking him up.

In this tracking as we go across the United States there is a hole in it we think is important. I named the existing military facilities. There is one place that we are not going to be tracking him. It isn't going to be continuous from the time we fire the retrorockets between White Sands and Eglin. He will be out of touch with us if we don't put a station in Texas. So we envision putting a station in Texas to make this tracking continuous to give the exact data, late data and complete data to the recovery forces as this is a very critical position.

With Project Mercury, the requirement is that we talk to the man 10 minutes out of every 15. That is the way it is set up at the moment.

This thing stemmed from discussions with some aeromedical people. This places some 12 to 14 telemeter stations and these stations will be $400,000 to possibly $500,000 apiece. They would be on ships, or islands. We would put them where expedient. We would ask the Pacific Missile Range to use their land possibly to operate it for us if they can, and they would like to, for the telemetering data on Project Mercury there will be 12 to 14 telemetering stations involved.

That completes the presentation on the tracking and data acquisition. There was a second line on the program referred to the Pacific Missile Range.

Mr. ANFUSO. Mr. Buckley, before you go into that—Mr. Chairman—I would like to ask you a question about what you said. You said you would talk to the man every 10 minutes. Who are you talking about—the man in the capsule?

Mr. BUCKLEY. Yes, sir, the man in the capsule.

Mr. ANFUSO. Supposing something should happen to him. Suppose he is unconscious or knocked out temporarily?

Mr. BUCKLEY. I want to make it understood, we are talking to him for 10 minutes out of every 15 minutes. I said it a little bit wrong. The stations will be approximately 15 minutes apart and we will talk to him 10 of the 15 minutes, is the present requirement.

If he gets in trouble, first of all, as you may have heard earlier, we have given every consideration to all the possible things that might happen to him—as many as we can. There is duplication in the life support system in the capsule so that if anything happens to it he can turn on the second one. In case of fire he can vent the capsule to the atmosphere and he is still in a pressure suit and so forth. You can't possibly protect him from everything, but on the other hand we are going to bring him out at the end of the next orbit if we feel there is anything going on that is wrong.

Dr. DRYDEN. He is instrumented, by the way. The man himself is instrumented so we know something about his physical condition.

Mr. ANFUSO. You know something about his physical condition all the time?

Dr. DRYDEN. All the time.

Mr. QUIGLEY. Even if he didn't tell you?

Dr. DRYDEN. That's right.

Mr. ANFUSO. He could be unconscious but alive and you know that. If necessary, you can bring him down right away, you say?

Mr. BUCKLEY. We could fire the retrorockets right away, yes, sir, but we would rather not because it is better to let him go for the extra half hour or so and bring him down in an area where we have very intensely concentrated recovery forces that can probably pick him out quicker.

The overall time, if you can let him go for 20 minutes and then pick him out, would be shorter than if you dropped him in the middle of the Pacific and then had to go looking for him and you can't possibly cover the Pacific, say, with the same concentration of forces. So this is the way it is planned.

Mr. ANFUSO. I just wanted to be sure that you are interested more in his life than in a scientific experiment. If you could preserve his life and abandon the scientific experiment, you are going to give preference to that.

Mr. BUCKLEY. But the quickest way to get him out is to let him go where we can drop him right in the middle of a lot of vessels.

Mr. ANFUSO. That is saying the same thing. That is trying to save his life too.

The CHAIRMAN. You are going to use all the automatic scientific inventions that are available to give you communications with him to show his physical condition, such as——

Mr. BUCKLEY. Yes, sir, he is thoroughly instrumented as to respiration and blood pressure.

The CHAIRMAN. Are you going to use the data there to broadcast his heartbeat?

Mr. BUCKLEY. It is envisioned that there will be at each of these telemetering stations on the ground a doctor who can talk to the man and also will have in front of him a display of his heartbeat and his respiration, his skin humidity which is a measure of his nervousness, and so forth. All of these things will be displayed for a doctor at each station, who not only can talk to the man but talk to the control center at Cape Canaveral.

The CHAIRMAN. You report to him on things that are happening down here on earth. Is that the idea in your 10-minute interview with him every 15 minutes.

Mr. BUCKLEY. The doctor will talk to him. It will be to report to him where he is and confirm it, for his peace of mind certainly. But in addition to that the doctor will ask him certain questions and get certain answers from which he will evaluate the mental state he is in.

The CHAIRMAN. He is going to have the ability to broadcast himself?

Mr. BUCKLEY. Yes, sir.

The CHAIRMAN. He will be able to talk. It will be a regular telephone conversation?

Mr. BUCKLEY. That is right. It will be an over-the-telephone diagnosis the doctor is running, or rather an over-a-radio diagnosis.

The CHAIRMAN. So every 10 minutes out of every 15 minutes you will know what his physical condition is?

Mr. BUCKLEY. Yes, sir.

The CHAIRMAN. And mental condition too, you will be talking to him and he will be reporting back to you, is that correct?

Mr. BUCKLEY. That is correct, sir.

The CHAIRMAN. Mr. Fulton.

Mr. FULTON. How much of the orbital path in miles will be over the jungles in Africa and how much will be over untracked portions of water? Granting that the Atlantic is covered, how much water will be left with no tracking whatever?

Mr. BUCKLEY. A tremendous amount, sir.

Mr. FULTON. Can you give us first as to Africa, and then how much of the course is over Africa and over part of the jungle there?

Mr. BUCKLEY. It is over Africa for 3,500 or 4,000 miles.

Mr. FULTON. What kind of country is in Africa?

Mr. BUCKLEY. First it is over desert and then there are some mountains and then the grassy plains and some jungles and grassy plains. I guess it is some of everything.

Mr. FULTON. So it is a lot of wilderness area?

Mr. BUCKLEY. That's right. And that is why it is so important to be sure he is in orbit. If he is in orbit he keeps on going. If he isn't in orbit, you want to stop him before he can possibly go that far.

Mr. FULTON. This is off of Madagascar. How far is it then across before he hits Australia, because he is obviously just over water with no tracking stations or anything.

Mr. BUCKLEY. Yes, sir, another 3,000 or 3,500 miles.

The CHAIRMAN. You are purposely avoiding Russia because you don't want him to bring down the gadget in Russia, do you?

Mr. BUCKLEY. That's right. That was one of the considerations.

The CHAIRMAN. So you have got to orbit him below and across Africa and around by Australia so as to avoid Russia. That is right, isn't it?

Is that correct?

Mr. BUCKLEY. That's right, sir, yes, sir.

Mr. FULTON. Wouldn't it be safer to go through Russia maybe and ask for their cooperation? Aren't we more interested in the safety of the man than in disclosing the capsule?

The CHAIRMAN. I would rather take my chances in the jungles. [Laughter.]

Mr. FULTON. We should have an answer. What are the factors? Was there any factor of sacrificing the man's safety simply because we didn't want him going over Russia by agreement or otherwise?

Dr. DRYDEN. No, that is not a consideration. The consideration is the location of the stations, the ability to bring him down in the Atlantic if he is not in orbit so he doesn't come down in Africa and the Pacific.

The CHAIRMAN. As a matter of fact, you have more water expanse on the route you are taking than if you took the northern route over Russia.

Dr. DRYDEN. Once he is in orbit he will stay there for many days, unless he fires the retrorockets. So if he really gets in orbit there is no chance of his coming down in Africa or in the Pacific Ocean.

If he doesn't get in orbit, we want to bring him down in the Atlantic.

Mr. FULTON. Then in answer to the chairman's question, the fact that he would be passing over Russia was not a determining factor as to your orbited course for the first man in space, was it?

Mr. BUCKLEY. That was not a determining factor. The factors considered were his safety, getting him launched safely, being sure he was in orbit, and bringing him out safely.

Mr. FULTON. If it had been more safe to route him through Russia, you would have put him through Russia, wouldn't you?

Dr. DRYDEN. Only with their agreement, I think.

The CHAIRMAN. That is the point. You have got an international proposition putting him over Russia. Isn't that correct? Would you want to go ahead and send Mr. Mercury over Russia there without permission of Russia?

Dr. DRYDEN. I think we would not want to take this responsibility. They might find some way to bring it down.

Mr. FULTON. Would the course over Russia have been safer?

Dr. DRYDEN. I don't think so. Russia has a few very large cities. It also has an awful lot of wild country, as I understand it.

Mr. MILLER. Will the gentleman yield?

Mr. FULTON. Yes.

Mr. MILLER. Is there any place that you run this orbit around the world, even in the United States, where it is safer where a man is up in flight and in orbit? When you get out into the western part of this country and the man comes down in the middle of the desert in New Mexico or Utah, up on the plateau, or any of these places, you get out into the Pacific or Atlantic——

Mr. FULTON. California?

Mr. MILLER. California, put him down in the middle of the desert, there is no place that is safe.

Dr. DRYDEN. We have lost airplanes which have taken several days to get to, as I remember.

Mr. MILLER. There is no place that is safe in the sense that one may be better than the other. You get out into the Atlantic and you get within 40 miles of no place, and it is just as bad as if you are 40 miles from no place in the Pacific.

Mr. FULTON. Would the gentleman yield?

Mr. MILLER. Yes.

Mr. FULTON. But it is a worthwhile inquiry to find if the orbit has been set with regard to political and international considerations, rather than scientific considerations, and the safety of the man, so that we should decide which is the safest orbit, and we should be told the factors and the judgment that made the course.

Mr. MILLER. Isn't that academic? You have confidence in these people who are doing this thing, and I have. You are not a scientist. I am not a scientist. You know a lot more than I do, but nevertheless your sum total of science doesn't equal perhaps one of theirs. You have got to depend on people in Government. People have to depend on your judgment as a Member of Congress.

They don't ask you for specific information why you did this or why you did that. I have perfect——

Mr. FULTON. That is why I am on this committee—to check.

Mr. MILLER. Maybe you are. I am on this committee to try and help these people whom I have perfect confidence in, and whom I feel people have perfect confidence in, to get their job done. We can't go into minutia of what they are doing without embarrassing yourself or them.

Mr. FULTON. Mr. Brooks, the chairman, brought up the question of the flight over Russia——

Dr. DRYDEN. May I say again the main objective of this whole project is to bring the man back safely. We can put him up in the air any time just like the dog was put up.

Mr. MILLER. I may be very naive and may be a very trusting guy, but when these people who have devoted their lives to this thing tell me they are doing it to the best of their ability and this is their judgment, personally I am going to accept that.

The CHAIRMAN. I want to say here to Dr. Dryden that I have got confidence in him and his organization there. I think he has done exactly the right thing; in the first place, by avoiding Russia we stay out of diplomatic problems. Second there is no chance of after a flight is brought back of it getting into Russia's hands. We don't want that. We don't want that man getting into Russian hands after he has made the flight.

Third, I think that he has covered the best part of the globe there, by having a greater expanse of water by that route than he would have if he went over Asia and Europe.

Mr. ANFUSO. Mr. Chairman, may I add to what you just said, also the statement Dr. Dryden made a moment ago. You didn't want this man to go over Russia because the Russians would try to find some method of bringing him down. Did you say that, Dr. Dryden?

Dr. DRYDEN. Yes.

Mr. FULTON. Is there any factor of staying out of Red China in planning this orbit?

Dr. DRYDEN. The same reasons. I think the most highly classified thing about this project will be the frequency which fires the retrorocket, or the code which fires the retrorocket.

The CHAIRMAN. It is very important that no other nation or no other people tamper with that?

Dr. DRYDEN. No other person knows it.

Mr. MILLER. This guy may be forced into a forced landing.

Dr. DRYDEN. We don't want a radio hampering the retrorocket.

The CHAIRMAN. You don't want to bring him down where there is no landing field.

Dr. DRYDEN. Right.

The CHAIRMAN. Just go ahead and proceed with your statement.

Mr. BUCKLEY. The other part of my presentation, as you see by the program, is a mention of launching facilities at Pacific Missile Range. During the year 1961 we are going to put four vehicles in a polar orbit. The only place you can safely shoot on a polar orbit now and probably then will be from the Pacific Missile Range firing south.

It is the only place you can shoot and not have boosters drop where there are people. In doing this the Pacific Missile Range would provide the local tracking and the local instrumentation, but we intend to fire a number of booster configurations that will fit our scientific purposes, and there won't be launching equipment available for the specific things we use at that time, especially since some of the equipment in that area will be there for military purposes and will not have facilities to work on second and third stages, and on the scientific payloads at the top of this.

So it is felt it will be necessary to put the special equipment in for our launchings, and on the basis of the requirement at both of the military bases, any special equipment that has to be used uniquely by a user at first, the first user is expected to pay for this equipment.

So there is an item in the budget then for $3 million for launch pads, blockhouse, checkout instrumentation, and a certain amount of the facilities in that area. The roads and utilities will be in there normally because the Pacific Missile Range will have them in there.

Mr. MILLER. Those will be available, though, for future operations?

Mr. BUCKLEY. Yes, sir. This is a range like the one that AMR has built up. The first user supplies something and then other people adapt it or make use of it as it is. This is the way AMR has built up and it is the way PMR will slowly build up, too.

The CHAIRMAN. Thank you very much, sir.

Dr. SILVERSTEIN. Mr. Chairman, I would like to mention one thing on this same area. The material that was discussed by Mr. Buckley on the global ranges, these three networks, is shown on page 389 of

this green book and they are in the amount of $10 million for the ranges. The item for the PMR he mentioned was $3 million. That is shown on page 387 of this green book as a reference point.

The CHAIRMAN. The next witness is Mr. John W. Townsend, Jr., Beltsville.

STATEMENT OF JOHN W. TOWNSEND, JR.

Mr. TOWNSEND. Gentlemen, as you recall, the Congress last year authorized the construction of the only major new facility requested by the NASA. This facility is called the Beltsville Space Center, and is located physically at about the intersection of Glendale Road and the Baltimore Parkway. In other words, roughly in a northeast direction from Washington.

I am going to discuss this morning our plans for additional facilities at the Beltsville Space Center.

First, of all, I would like to review for you the reason why we are creating the center at Beltsville. There are two principal reasons. First, it provides a sorely needed additional facility, additional national facility, particularly in the area of space science research.

Secondly, Beltsville will provide a reservoir of highly skilled technical manpower to assist in the conduct of the NASA program.

I would like to give a little background on both of these last two points. First of all, if you will recall from Dr. Newell's presentation and other presentations that have preceded this one, up to this point the United States has only launched a very few satellites. The plans that you have seen developed before you call for the launching of a large number of satellites. Our facilities that are presently available to us are essentially those that were created for the sounding rocket program which began in about 1946, and were added to slightly for the International Geophysical Year. These facilities are not adequate for the conduct of the projected space science program.

At Beltsville we don't plan to do it all. As a matter of fact, we are talking in terms of perhaps 10 to 20 percent of the effort in certain lines of research. The rest of the work will be done by colleges, universities, contractors, and other governmental laboratories.

In connection with the second point, the reservoir of highly skilled manpower, the problem here simply is in liaison, in coordinating, in correlating, and in aiding and abetting the various contractors that will do these jobs that you have had described to you.

For example, people at the space center will coordinate the activities of the various contractors that create these space vehicles.

Further, we will do contract monitoring from Beltsville and we will assist by giving advice to the various missile contractors and the specialty contractors.

The additional facilities at Beltsville are outlined on this chart along with the estimated cost. It consists of three buildings and a utilities installation. I will go through these three buildings one at a time here.

You will notice that in each case the cost of the building construction is broken out and the cost of the specialized research equipment which goes into that building is broken out.

First of all we have what we are calling the central flight control and range operations building. This is our nerve center, the hub of our

space activities. Here we will have a large room in which will be located what you might call a satellite status room. There will be located here the end points of the various communications networks from all of these tracking facilities that Mr. Buckley described, and from many of the other facilities.

Here at Beltsville and in this building the various data that are sent in from the centers will be analyzed—rectified, we call it, or turned into a useful form, and then instructions will be sent back to the stations.

For example, a satellite is launched. As the various tracking stations intercept the radio beam from the satellite, information will come in to Beltsville. This will be turned into a form useful for computers, and put on a large computer that is in Beltsville. The computer will come out with a preliminary orbit, back out to the stations again will go instructions to tell the stations what the preliminary orbit is and when to look for the satellite.

Further, instructions can be given the stations such as commanding the satellite to turn on its telemetering transmitter or to give other specialized instructions.

This particular research equipment associated with this center activity is connected mainly with the computing facility that determines these orbits and with the data handling and rectification equipment, and finally with the specialized communications gear that must be present here.

Some of the same things has gone on right here in the Washington area in the Vanguard control center, which is physically out at the Naval Research Laboratory. Currently the inputs from the various minitrack stations are brought together in one place and intsructions sent to a computer downtown.

Again it is the problem of a much bigger program that faces us now than we had during the IGY that forces us into a new type of operations here.

Mr. MILLER. Will the data gathered, say, from the Pacific Missile Station be worked over at this central flight control?

Mr. TOWNSEND. It depends entirely, sir, on what the particular data involved are. If it is tracking data, for example, this would probably be fed back here. If it is data from, say, Project Mercury or something where an immediate command must be given right at that point in time, it might well not. They have special requirements. But in general we will act as the central control point, giving the station managers their instructions. These instructions may involve just making some measurements and shipping the magnetic tape back here to Beltsville where we will read it—a term we use—and play it into the computers and then come out with the data which we hand to the scientist or to the project engineer in a finished form.

Mr. MILLER. Where does ARPA do this same type of work with respect to its missiles?

Mr. TOWNSEND. They have establishd what they call Project Space Track, I believe is the name. This has a different purpose. This is somewhat the same type of activity, but they have a different viewpoint toward this. Here they are trying to collect data on all types of objects in space, and particularly the so-called uncooperative objects and assembling and computing information on these things.

Mr. MILLER. Then the work that they are doing at ARPA and at the others, the military, is gathering this data and trying to read those objects that may come over and that could be hostile in nature so that their equipment must be kept available for that at all times?

I am just trying to avoid the necessity of someone saying, "You are duplicating the equipment that they have out here."

Dr. DRYDEN. May I give you——

Mr. MILLER. That is what I am after.

Dr. DRYDEN. A little secondhand information. There has been set up experimentally a space-track center which is regarded as a research and development model for what would ultimately be a center located at the air defense point.

In order words, you remember when the SAGE system was worked on at Boston, they worked out a pilot system before they installed the actual system. So they now have a pilot system of the defense center of space track. Later they will build this National Defense Center.

Mr. MILLER. I just want to make sure there is no duplication.

Mr. TOWNSEND. We, now, for example, trade information back and forth. It is a very important trade with the space track people during Vanguard and other space operations, and that presumably would continue.

Mr. MILLER. I understand that the work done on Discoverer II now is being computed at the Stanford Research Institution, because they have equipment that can do it and they are sending it up there.

Dr. DRYDEN. Yes. Probably a lot of our data, the magnetic types that were spoken of, the volume will be so great there will be many computing centers throughout the country at universities and elsewhere used to reduce the data.

Mr. MILLER. Thank you, Mr. Chairman.

Mr. TOWNSEND. The second building we are calling the Space Sciences Laboratory. This will be a building containing laboratories and offices. Here we will do our basic research and our research and development on the various scientific experiments and allied areas.

The research equipment to go into this building is highly specialized scientific equipment such as particle accelerators to simulate the energies of the particles we expect to run into in space, mass spectrometers which are devices for determining what gases are present in a mixture in say an atmosphere, and how much of each of these gases are there.

High vacuum systems to simulate the very high vacuum in outer space and to test our little sensing instruments, the end organs or the device that gathers the data for the scientific experiment, and then devices such as ultra-violet monochrometers, which is a scientist's way of saying a device to calibrate the ultra-violet astronomy detectors that will develop these data on the origin of the cosmos that Dr. Newell spoke of earlier.

The third building is an instrument construction installation laboratory. This is a very important building to us because it is here that we will construct these payloads or a few of them that have been described. This means the actual objects themselves that fly out into space, the rocket nose cones, and the space probes. The building contains shop facilities, it contains "clean" rooms which are necessary

for assembling the delicate instruments, and it contains a facility for testing our instruments. This is a very important function because reliability is of paramount importance in this type of research. Our equipment is hands off. Once it has flown it must work. This means therefore we have to be very careful before we fly an experiment to put it on say a shock and vibration machine and to simulate the very worst conditions it will encounter during the firing.

After it has passed these tests, we will put it in vacuum chambers and evacuate it to simulate outer space and then heat it with infrared lamps and cool it with a refrigeration system to simulate the temperature variations it will run into as say it orbits through the earth or as it goes out into space.

The utilities I think are self-explanatory. This consists of a heating plant and other utility construction for the present phase of construction at Beltsville. We have a temporary pad and a temporary boiler which will be replaced by this more permanent facility.

The total estimated cost of the additional facility at Beltsville is $14 million. I would like to close with the comment that the facilities here at Beltsville are integrated into the program that you have seen presented. The planning for Beltsville goes along with the planning for the various technological developments, the science planning and the operations that were covered by Mr. Buckley.

Thank you.

The CHAIRMAN. Thank you very much.

Mr. MILLER. Mr. Chairman.

The CHAIRMAN. Mr. Miller.

Mr. MILLER. I think that the record, because this may come up on the floor, in the case of the Defense Department, the Corps of Engineers, or the Bureau of Yards and Docks takes care of all of the building of facilities, purchases of land—who will do this for NASA?

Dr. DRYDEN. We do this by architect-engineer contracts and direct competitive bids for construction.

Mr. MILLER. Direct competitive bids?

Dr. DRYDEN. Yes.

Mr. MILLER. By contract, but you enter into the contract, so that no other agency of Government——

Dr. DRYDEN. There is no intermediary.

Mr. MILLER. No intermediary. The General Services does not enter the picture with you?

The CHAIRMAN. All of this has the approval of the Bureau of the Budget?

Dr. DRYDEN. Yes, sir.

The CHAIRMAN. And it will be open competitive bids on all of this?

Dr. DRYDEN. That is correct.

Mr. QUIGLEY. Mr. Chairman, could I ask one question?

The CHAIRMAN. Mr. Quigley.

Mr. QUIGLEY. What is the completion date of all of these facilities?

Mr. TOWNSEND. That is one reason the need for the funds is urgent. For example, we would like to use some of the facilities during the Project Mercury operations. You remember the schedule yesterday that showed flights beginning in 1960, early in calendar year 1960.

Dr. DRYDEN. Twelve to fifteen months. There is a total given of 26 months for the whole job.

Mr. TOWNSEND. For a turnkey job. We hope to have some of the more vital functions inhabiting these buildings about a year from the time that the authorization and the appropriation is made.

The CHAIRMAN. Any further questions?

Mr. CHENOWETH. Mr. Chairman.

The CHAIRMAN. Mr. Chenoweth.

Mr. CHENOWETH. I would like to inquire concerning the staff that you have at Beltsville, your present activities, when they started.

Mr. TOWNSEND. The staff that is to comprise the Beltsville Space Center came from a number of places. Actually, in some cases it hasn't been brought together physically yet.

First, a group from the Langley Research Center of the old NACA, the group that is doing Project Mercury, comprises a part of the Beltsville Space Center. Then the Project Vanguard people that were transferred from the Naval Research Laboratory compose a second part.

A third group that came from NRL but was not associated with Project Vanguard is an upper-air physics group, particularly the scientific line. And other small groups from other places have been assembled to provide the core for Beltsville.

Mr. CHENOWETH. I wanted to inquire why Beltsville was selected if you didn't have the facilities which were required for this work, why Beltsville was selected as the site for this activity?

Dr. DRYDEN. In the first place, the bulk of the people are in this area now. The Vanguard group came out of NRL. They are now housed in some adjoining buildings belonging to the Naval Gun Factory that have been converted for their temporary use. One group is located in a building at Silver Spring. These are two of the large elements in the Center.

The points were this: The communications from our networks come into this general area now. Washington is the center of international communication. We do not need to put in extensive new facilities. There is a major cable of the telephone company running along the Baltimore-Washington highway. We are just a few miles off of this. So we do not have a large expense for putting in communications to distant points.

We wanted to be close to Washington because of the ease of communication with university contractors, business contractors who come into the area. We did not think it appropriate to locate this in downtown Washington because it is, as you can see, in addition to a contract monitoring function, it has laboratory functions as well.

Mr. CHENOWETH. I would like to inquire, Doctor——

Dr. DRYDEN. The land was available without any cost as a part of the Agricultural Research Center.

Mr. CHENOWETH. Is it the policy to scatter these facilities as widely as possible or to concentrate them in an area like this?

Dr. DRYDEN. We are rather widely scattered. Our present installations are in California, Cleveland, Ohio, in Virginia, and we have the headquarters here in Washington itself.

Mr. CHENOWETH. We are spending rather large sums of money in this program, and will continue to do so. I think perhaps the general economy might be taken into consideration in the location of some of these sites, these facilities—unless there is some compelling reason why

they should be located in an area which is already very heavily congested.

Dr. DRYDEN. The nature of the personnel is such that we think it essential that they be in a metropolitan area. We have operated some activities at remote locations, but in this particular activity and its close contact with universities, we felt that this was the proper location.

Mr. CHENOWETH. How many will be at Beltsville? What will be the total?

Dr. DRYDEN. I think it is 1,200 in the budget or 1,250.

Mr. CHENOWETH. You have 1,250 there now?

Dr. DRYDEN. Of which we have about 800, I think I mentioned, already scattered around various locations.

Mr. CHENOWETH. Thank you very much.

Mr. RIEHLMAN. Mr. Chairman, could I ask just this one question. This planning, Dr. Dryden, for your expansion of facilities out here at Beltsville, are you looking into the future as to what needs will be for the next 3 or 4 years? Are these plans sufficient to meet the needs in the next 3 or 4 years ahead?

Dr. DRYDEN. This completes our presently planned program. If you ask me to read the future, I don't know what to tell you. It depends on the size of the program, how the program develops. But this is planned to give us, with the facilities under construction now, a plant which meets our immediate program needs.

Mr. RIEHLMAN. For how many years?

Dr. DRYDEN. For the foreseeable. I say if the amount of money going into this program multiplies by three, then this needs reexamination. If it is of the order of the plans that we have put before you, this meets the needs as we see them.

Mr. RIEHLMAN. You really don't believe that this program is sufficient for the future, do you?

Dr. DRYDEN. This program that we have laid down we think is sufficient for the immediate future. What the distant future is, I don't know. Let me answer it this way. We are not proposing to carry this program as an in-house governmental operation. The laboratory activities that we inherited from NACA with about $100 million appropriation carries roughly 8,000 employees. The other $350 million that we are asking you for will be handled with 2,000 employees. As mentioned by Mr. Townsend, we plan to do something between 10 and 20 percent in-house because you need people who know what the game is, to evaluate what other people are doing. We have run into this many times before. You must know how to judge the claims made and you must recognize good work when you see it and poor work when you see it.

So in view of the fact that we are attempting to do this through a contract, largely a contract activity, you come down to a question of how many people does it take to administer a million dollar contract money adequately? What I have said is that this meets our plans as we see them at the moment.

Mr. RIEHLMAN. The thing I was trying to arrive at was whether or not you intended to expand your in-house activities, and if so, whether these facilities will be sufficient.

Dr. DRYDEN. It has been the policy of Dr. Glennan to keep the in-house expansion to that which is necessary to do a good job of organizing and using the resources of the country in this program.

Mr. RIEHLMAN. That is all, Mr. Chairman.

The CHAIRMAN. Thank you very much.

Our next witness is Mr. Donald Heaton on propulsion activities.

STATEMENT OF DONALD HEATON

Colonel HEATON. Mr. Chairman and gentlemen of the committee, I will cover the third and final item in the space flight development of the facilities package. This item comprises three facilities. Two of these are in support of the Vega and the Centaur programs, and the third is for research and development in advanced chemical rockets.

You will recall that both the Vega and the Centaur programs were described to you a couple of days ago by Mr. Rosen. You will recall also that in both the case of the Vega and the Centaur we are talking about advanced vehicles based on the use of the Atlas missile as the first stage, but requiring the development of altogether new upper stages.

The major and the basic development task, both in the case of the Vega and the Centaur, is the development of these new upper stages, the ones we mated to the Atlas missile.

One of the most important things we must bear in mind in laying down and conducting the development of both of these vehicles is the vast importance of maintaining a very high degree of reliability in the complete vehicles. For example, we don't want lack of reliability in these vehicles to preclude our use of them in the future for extensions of the man-in-space program.

So reliability is of utmost importance.

Furthermore, it is very safe to say that the reliability of the overall Vega and Centaur vehicles can't possibly transcend the reliability of these new second stages that we are setting about developing. The development of each of these stages is closely akin to the job of developing a ballistic missile. The stages include components which must be capable of performing all the functions of, for example, an IRBM and even more. Like the IRBM, for example, each of these vehicles includes rocket engines and associated propellant systems, guidance elements, and control equipment.

Consequently it is imperative that the development programs for these vehicles include a very rigorous program of static testing to insure that the designs we adopt are in fact reliable. Also once development of the vehicles is completed and they are in active production, it is necessary that each vehicle produced be subjected to a very thorough flight readiness firing checkout to verify the functioning not only of the components indvidually but of the working of all of the components together as a complete stage system.

We have determined that Vega and Centaur each needs a new captive test standard to conduct this program of research and development testing and of flight readiness firings.

As you may well know, Convair Astronautics, San Diego, is a contractor not only for both the Vega and the Centaur vehicles, but also

for the Atlas missile. In the interest of efficiency in the use of the first team on Convair's development and testing engineers, the ideal location for both these new test stands is in Sycamore Canyon. Sycamore Canyon is a Government test site only about 11 road miles from the Convair Astronautics plant. It is also currently being operated by Convair and it is being solely occupied by Convair.

The CHAIRMAN. Where is Sycamore Canyon?

Colonel HEATON. All right, sir, I will show you. This gives you all a view of the area in which Sycamore Canyon is situated. You will note the significant points here.

The CHAIRMAN. What State is that in?

Colonel HEATON. San Diego, Calif., sir.

Here is San Diego itself. Here is the main highway going north and northeast. Here is the location of the Convair Astronautics plant and about 9 miles as the crow flies and about 11 miles by road we have Sycamore Canyon. It is an isolated test location.

Mr. MILLER. What town is it near?

Colonel HEATON. The nearest town of any size is El Cajon.

The CHAIRMAN. How much money are you going to put in Sycamore Canyon?

Colonel HEATON. We are requesting for the construction of these two stands, $1½ million for the stand for the Vega program, and $1¾ million for the stand for the Centaur program.

Dr. DRYDEN. May I interrupt to just make one point. These vehicles also all use the Atlas missile booster as the lower stage. The other pieces are made by other contractors. Convair has a job of modifying the Atlas. Instead of having the nose cone on it, the 10-foot diameter is carried out, as you recall from the other presentations, in a cylindrical shape. So Convair then assembles and tests the vehicles. Other components are made by other contractors. I think we mentioned in the Vega case there is a GE contract on an engine, and so on.

To the problem is this: We must have facilities to check out these vehicles, to assemble them and check them out. It is almost essential to do it in the same place that the Atlas is tested out. There is a military twist to this. We are here using a military guided missile booster, and that aspect of it has some classification. This is not a completely open subject. We cannot economically find other people who could take an Atlas missile and modify it at a cost anywhere near comparable to the people who built it in the first place and who have all the tooling.

This is another example of the fact I mentioned yesterday that the true cost of the space program doesn't really show up because we benefit by all the guided missile technology.

To do this particular job, to build the tankage for the second stage, all the tooling is present in the plant furnished at Government expense and charged to the ballistic missile program.

We find the situation that in order to do these development jobs we must have facilities. We are locating our facilities on the same Government-owned site that the military have supplied to Convair for their tests of the Atlas booster.

The CHAIRMAN. That was the question I was going to ask you. Is it Government owned?

Dr. DRYDEN. It is Government owned.

The CHAIRMAN. How much land do you have there?

Dr. DRYDEN. I do not know what the size of it is.

Colonel HEATON. I don't know the exact acreage. However, there is extensive Government-owned property all around here. It is adequately separated from nearby population centers for safety from the hazard point of view, and also from the nuisance point of view.

The CHAIRMAN. Any questions on it?

Colonel HEATON. You will recall a presentation by Mr. Rothrock of NASA the day before yesterday, I believe it was. This presentation dealt mainly with nuclear and electric rocket propulsion systems. You will also recall that this presentation was concerned principally with the importance of high specific impulse in rockets. Specific impulse was defined as the efficiency with which propulsion systems use their propellants in producing thrust.

High specific impulse is of very great importance, particularly for the top stages of multistage vehicles. I believe Mr. Rothrock likened this factor to miles per gallon in the case of an automobile.

A large payoff in terms of payload per dollar awaits an expanded program in attempting to find out how to exploit the high specific impulse which is latent in very high energy liquid propellants when used in chemical rockets. This is a very important area.

Unfortunately, however, many of these propellants we are concerned with here—for example, fluorine—are very toxic, very corrosive, very reactive.

Consequently, the present research facilities, such as the NASA Lewis Research Center in Cleveland and the Jet Propulsion Laboratory in California, are severely restricted in their use of these very ugly, but very advantageous propellants by reason of their proximity to urban areas.

The indication, therefore, is that we require a new central site specialized for the use of very toxic propellants. Therefore, it must be located in an isolated area. As soon as we acquire this facility, it will first be used to continue the research work in very high energy toxic liquid propellants presently being conducted by the Jet Propulsion Laboratory and by the people from the Lewis Research Center, Cleveland.

In this new facility they will be able to expand the scale of their activities, both as to size of thrust and as to frequency of firings.

The location of this new facility is still under study. However, the location will be one which will meet the criteria I mentioned.

To recapitulate, we are asking for——

Mr. FULTON. That location is under consideration?

Colonel HEATON. In the first place, we haven't limited our consideration. There are many obvious ones we always look at. One consideration would be to get one as near as possible to the activities of the Jet Propulsion Laboratory. That would be a consideration, but it is not the sole one by a long shot. We want this to be located on Government property. We don't want it to be restrictive in our selection of the contractors which can later use this facility for the research and development using these high energy propellants.

So we want it on Government property. That is one criterion we are looking toward. Certainly we have to have the facilities in an isolated location. It should be in much the kind of terrain you find in this area, but this isn't the only place in the United States you find it.

Mr. FULTON. Will you just list the places under consideration at the present time?

Dr. SILVERSTEIN. May I speak on this? We have a team established to do a site survey. This team was established after we set up an initial team to decide the kind of facilities that ought to be at the site. We have gone through the first exercise but the other team to locate the site hasn't really gotten into action yet. We expect that they will be very shortly.

Mr. FULTON. There is one site recommended in California, obviously, already. I wondered if there were any more outside of California.

Dr. SILVERSTEIN. They will make a rather broad survey, I think, Mr. Fulton.

The CHAIRMAN. Let me ask you this. Will you make public the fact that you are looking for a site?

Dr. DRYDEN. We are doing so right now. This is an open hearing.

The CHAIRMAN. Is this an announcement now? Could you then give us the names of those who are on the team who will make the survey and the time when they will make the survey so that the interested areas may have a reasonable chance to make an offer?

Dr. SILVERSTEIN. The chairman of the team is Mr. Jack Parsons, associate director of our Ames Laboratory. We will give you the members of the team and the point of contact.

Dr. DRYDEN. We will put them in the record, Mr. Chairman.

(The information requested is as follows:)

SITE SELECTION COMMITTEE FOR PROPULSION FACILITY

1. John F. Parsons, Chairman, Associate Director, Ames Research Center
2. N. Philip Miller, Chief of Construction Engineering Division, at Goddard Space Flight Center
3. Col. Donald H. Heaton, USAF, Assistant to Director for Propulsion and Boosters (NASA Headquarters)
4. A. O. Tischler, Chief, Liquid Fuel Rocket Engines Program (NASA Headquarters)
5. Dr. Frank Goddard, Section Chief, Propulsion Division (JPL)

The CHAIRMAN. They are making what kind of survey now?

Dr. SILVERSTEIN. We have completed an initial survey of the facility requirements. Once we establish exactly what it is we are putting in the site, then we set up the site survey team which we have now picked and we will initiate the study very quickly.

The CHAIRMAN. So the team has not gone out yet?

Dr. SILVERSTEIN. Not as yet.

Mr. CHENOWETH. May I inquire, Mr. Chairman?

The CHAIRMAN. Yes.

Mr. CHENOWETH. Will this team be more or less a continuous body?

Dr. SILVERSTEIN. No, they will operate over a period of time until they finish their mission, which will be to select a site.

Mr. CHENOWETH. Will there be other sites that they will be exploring from time to time?

Dr. SILVERSTEIN. They will select a site for this particular propulsion facility.

Mr. CHENOWETH. But will there be other facilities for which they have to select sites?

Dr. SILVERSTEIN. It wouldn't be the same team. We have specialists here who were expert in this particular area of work.

Mr. CHENOWETH. This won't be a general team, then?

Dr. SILVERSTEIN. No.

Mr. CHENOWETH. Do you have such a team for general facilities?

Dr. SILVERSTEIN. No, sir. We generally find that the requirements for the team are so heavily dependent upon the kind of thing we are looking for that we set up separate teams for each job.

Mr. CHENOWETH. You select a new team each time you want a particular site?

Dr. SILVERSTEIN. Yes, sir.

Mr. CHENOWETH. I see.

The CHAIRMAN. Do you give public notice of that? For instance, looking for a Government property, there are several hundred thousand acres in Louisiana that they say are surplus to Government needs. Look at that; or look in other areas.

Is there any effort to go over this surplus Government property?

Mr. CHENOWETH. We have some canyons in Colorado, too.

Mr. FULTON. We have also got Washington, D.C.

The CHAIRMAN. I think everybody on the committee has surplus land they would be interested in presenting to the committee.

Mr. MILLER. I withdraw the Eighth District of California. We have no places to put it in Alameda County.

Mr. FULTON. Will the gentleman yield? When there is mention of just one State and one location under consideration and then there is no mention of any other possibilities, when I keep asking for possible other geographical sites, it does leave an inference that I do not think the Agency wants to leave.

Dr. DRYDEN. We do not want to leave that inference.

Mr. FULTON. Then I think you should have in the record some possible geographic sites that would be suitable—Alaska, or Louisiana—and not just leave it standing on some place very close to JPL—which it looks obvious is going to be selected through some method of selection through a committee.

I think it leaves the wrong impression with the committee, and I don't want you to be under that circumstance.

Dr. SILVERSTEIN. Mr. Fulton, my only hesitation here is that I don't know what States I would put down that I could be accurate enough about until I make the study. I hope you will bear with us until we get far enough along in our study.

The CHAIRMAN. I want to say this, too. I don't think the committee should be the one to make the selection at all. I think you people should do it and use the best judgment. But in doing so, you certainly should give the people of the United States as a whole ample opportunity to present any arguments that they may have.

After all, you do have a large program and the space program above every other program should be a dispersed program. Surely in the space program distance is no factor normally, and if you feel like in the space program you have to be concentrated in one area,

it is certainly not in keeping with your thought of covering great distances in your activities.

I think we have said enough on this subject. I think we ought to go ahead with our witnesses. We have one more witness here.

Before everybody goes, I would like to take a moment out to outline the program. We now have reached the point where we are down to Mr. Abbott, who has introduction of program and facilities. Then we have seven more witnesses.

We thought we would operate this afternoon beginning at 2 o'clock. We were in hopes we would be able to finish one more witness, but we won't today. There is no use to begin now. So can everybody be back at 2 o'clock this afternoon?

Mr. FULTON. The session begins in 3 minutes.

The CHAIRMAN. We are not in session today at all. That is one reason I say 2 o'clock. We don't have any session. My thought further is this, that after we finish this, I would assign each section of this bill to one subcommittee so that when we go on the floor the subcommittee will have studied this backup book carefully and analyzed it, and if there is anything in the minds of anybody on any subcommittee, that that could be analyzed and developed in advance.

When we go on the floor, everybody would have a responsibility for putting this bill through. After all, this is a bill involving half a billion dollars. It is a bill that is entitled to our most conscientious effort. I notice there are about four sections here in the backup book. I am not going to undertake at this time to give them to the different subcommittees.

I will ask Mr. Ducander to give that thought. Then at the proper time when we finish this hearing, each section will be turned over to a separate subcommittee if there is no objection to this procedure, and the subcommittee will have the responsibility of studying this backup book. When we are asked a question on the floor of the House, the subcommittee then will be able—somebody on the subcommittee will be able—to give a prompt and a clear and concise answer to that question.

Is that arrangement all right with everybody?

All right, then, it is 12 noon. We will adjourn until 2 o'clock this afternoon.

(Thereupon, at 12 noon, the committee recessed, to reconvene at 2 p.m. of the same day.)

AFTERNOON SESSION

The CHAIRMAN. The committee will come to order.

This afternoon we have as our first witness Mr. Ira H. Abbott, on the introduction of program and facilities.

STATEMENT OF IRA H. ABBOTT

Mr. ABBOTT. Mr. Chairman, members of the committee, at this point there is a considerable change in subject matter from what you have been hearing before. I think it would be helpful if I gave a short introduction to the technical talks which are to follow to help orient you in this matter.

So far you have been hearing about the space programs of the NASA and the technical speakers who will follow, and I, would like to talk about some of the basic and applied research of the NASA related to and supporting aircraft and missiles as well as space craft.

In order to orient you in the budget book, I wish to speak specifically to the first group of items on the top of page 201. This group is entitled, "Aircraft Missile and Space Craft Research."

These items include support of the NASA plant in the sum of $16,670,000; support of the plant of the Jet Propulsion Laboratory, $8.156,500; and research contracts, $5,200,000.

I would also like to say that the material that you are about to hear in this section will also apply directly to a major portion of the funds listed under salaries and expenses about which Dr. Dryden will speak later.

The National Aeronautics and Space Act creating the NASA transferred to us all the functions and duties of the previous NACA. You will recall that the NACA was the principal aeronautical research agency of the Government charged with the responsibility for the conduct of aeronautical research to support and provide technical guidance for the aeronautical activities of both the military services and civilian groups. This function remains an important duty of the NASA.

In this research area we provide both basic and applied research information to the Department of Defense, to civilian agencies of the Government having aeronautical responsibilities, and to private industry. This research information is applicable to the problems of both aeronautics and space.

In the tradition of the former NACA, we work in close cooperation with the military and with industry, consulting with them about the technical problems of the new projects they wish to undertake, and focusing our research programs to solve the technical problems of both current and future designs.

At the request of the military services and other Government agencies we also undertake specific tests to assist in design and development problems whenever our talents and facilities are especially well suited to this chore.

Research activities thus serve the whole technology of the Nation in both aeronautics and space, whether applicable to civilian or military needs. These research activities are conducted principally in the various research centers of the NASA and at the Jet Propulsion Laboratory of the California Institute of Technology.

May I have the first chart. This first chart shows the location of these laboratories. The Langley Research Center is located at Langley Field in Virginia; the Ames Research Center at Moffett Field, Calif., just south of San Francisco; the Lewis Research Center at Cleveland, Ohio, and the High-Speed Flight Station at Edwards Air Force Base in California.

The Jet Propulsion Laboratory of the California Institute of Technology, of course, is located at Pasadena, Calif.

I would like to run through these facilities very briefly in order to give you an idea of their extent and the work they do. It will take two charts to show the aerial views of Langley Research

Center at Langley Field, Va., because this center is spread over a rather large area.

This first chart shows the facilities in what is called the east area, which was the original site. The facilities of the center are those which stand out prominently on this chart, and the other buildings that you see are those that belong to the Air Force on the Langley Air Force Base.

This other chart shows the west area of the Langley Research Center, and again the area encompassed by the research center is shown prominently on this aerial photograph.

This center was established in 1920. It employs about 3,200 people and has a capital investment of nearly $150 million. This center conducts work in the general areas of aerodynamics, automatic stabilization and control, structures, materials, aircraft operating problems, and hydrodynamics.

This next chart shows an aerial view of the Ames Research Center at Moffett Feld, Calif. This center was established in 1940, employs about 1,500 people, and has a capital investment of close to $100 million. You can see here very prominently some of the large wind tunnels of this center.

This laboratory is engaged in aerodynamic research, primarily high-speed aerodynamic research, and closely associated problems such as automatic stabilization and control and structural problems associated with aerodynamic loading.

This next chart shows an aerial view of the Lewis Research Center at Cleveland, Ohio. It was previously known under the NACA as the Lewis Flight Propulsion Laboratory, and this name describes the function of the center. This center conducts research in the many fields associated with propulsion of both aeronautical and space vehicles and with powerplants for space vehicles. It was established in 1942, employs about 2,800 people, and has a capital investment of about $130 million.

The next chart.

Mr. FULTON. What do the names Lewis and Ames signify?

Mr. ABBOTT. These names all commemorate people prominent in aeronautical research in this country. The Langley Laboratory commemorates Dr. Langley of Smithsonian fame. The Ames Laboratory commemorates the name of the man who was prominent in the early days of the NACA and served for a great many years as Chairman of the NACA.

Lewis occupied the position of Director of the NACA for—I forget just how many—but 20 years or more.

This is an aerial view of our facilities at the High-Speed Flight Station at Edwards Air Force Base in California. It was established in 1946 and employs about 300 people. The principal facilities at this station are Rogers Dry Lake, a small piece of which you can see right here—a truly exceptional landing area which was provided by nature; and the airfield facilities of Edwards Air Force Base, which of course are provided by the Air Force. Our capital investment in this station accordingly is only about $5 million.

This is our principal station for the conduct of high-speed aeronautical flight research using both advanced military airplanes and specially designed and constructed research airplanes.

This is an aerial view of the Jet Propulsion Laboratory of the California Institute of Technology which was transferred to the NACA by Executive order in December of last year. This laboratory was established near the start of the last war primarily for research and development of rockets.

In addition to its work on rockets, this laboratory has established a truly enviable reputation for its research and development work on guidance and control, materials, instruments, and missile and spacecraft engineering.

This laboratory employs roughly 2,400 people and has a plant value of close to $55 million.

These laboratories in combination represent a most important segment of the total capacity of this country for research applicable to aeronautics and space. Dr. Glennan joins me in extending an invitation to any of you who have not visited these laboratories to do so whenever opportunity provides; and for any of you who may have visited them, to revisit them.

We would be very happy to welcome you at any or all of them.

Mr. FULTON. With the chairman's permission, would you point out in that photograph the place and the portions that will be the new expansion program at the JPL?

Mr. ABBOTT. I am afraid I can't quite do it on this photograph. You see, this laboratory exists on a small shelf of land between a steep hill, which rises up in this neighborhood here, and drywash which surrounds it down in this area. At least it is dry except in flood times; but in flood times it is not usable.

The plan, as I understand it, is to move some of these facilities up this hill to places which I think are just off the top of this chart. There are some kinds of relatively flat spots up here.

The research at these laboratories include basic research to obtain a better understanding of the laws of nature; applied research, which supplies the great mass of detailed and accurate data required for the competent design of aeronautical and space vehicles; and specific testing of current designs that are required to optimize these designs and to ferret out sources of trouble.

Through close cooperation with the military services, private industry, and the scientific community, this research is closely coordinated with the other research efforts of this country and it is directed to the dual purpose of supporting current and foreseen development programs and of providing the fund of research information needed for the guidance of future projects that cannot now be clearly foreseen.

As listed on this next chart, this research information is used to improve practically all types of flying vehicles ranging from helicopters through vertical takeoff and landing airplanes, transport airplanes of all types, supersonic fighters and bombers, hypersonic airplanes which we do not yet have but which we hope for in the future, missiles of all types, but more especially in recent years such missiles as ballistic missiles, and antiballistic missiles, satellites, and spacecraft.

Mr. FULTON. What is the difference between supersonic and hypersonic?

Mr. ABBOTT. The difference is a rather nebulous one. In fact it is never very clear to me why one term should have priority over the other one, speedwise. However, some of these technical terms grow

up in the jargon of the industry. Actually hypersonic has come to mean a speed which is higher than supersonic and begins somewhere in the general neighborhood of five times the speed of sound.

So people ordinarily refer to everything from the speed of sound up to the general neighborhood of five times the speed of sound as supersonic, and above that as hypersonic.

I am afraid there is no real justification for this usage.

In addition to this research in our own laboratories and at JPL there is an urgent and continuing need for the NASA to augment its capabilities by utilizing the important research potential of the universities and other research organizations of the Nation through a vigorous program of research contracts. This program enables us to utilize economically and effectively the outstandingly fine facilities and talents existing in the universities and other research establishments.

Perhaps even more importantly, this program enables us to foster on a broad basis basic research in sciences relevant to aeronautical and space technology. In other words, through this program we can encourage throughout the Nation the building up of the talents and facilities that are required to accumulate the vast amount of basic knowledge and understanding that will be needed to permit a truly advanced space technology program such as you have been hearing about for the last several days.

An effective program to accomplish this has already commenced in the first 6 months of our existence. It includes fundamental research, especially relevant to aeronautical and space technology in four main scientific classifications. These are physical sciences, cosmological sciences, the life sciences, and the engineering sciences.

As of a few days ago action had been initiated to sponsor basic research valued at about $2,710,000 and comprising 50 projects. I cannot stress too highly the importance of this program in enlisting the scientific talent of this country, wherever it may be located, in the task of achieving supremacy in space technology.

In the presentations which follow, we shall try to give you some feel for the types and importance of our research. We have elected to organize these presentations about areas of applicability such as shown on this chart, rather than about academic disciplines.

In each application I should like to stress that important research problems are involved in such areas as aerodynamics, automatic stabilization control, structures and materials, propulsion with all its myriad problems, and in most cases with human factors.

The areas we have chosen to talk about are concerned primarily with aeronautics—that is, with aircraft and missiles. We have done this because you have previously been hearing about the space programs of the NASA, all of which are actively supported by our research work.

We have accordingly taken this opportunity to talk about some of our aeronautical research which remains an important function of the NASA. I would like to emphasize, however, that our research is concerned to at least an equal extent with the problems of space technology.

The first speaker will be Mr. John Campbell of our Langley Research Center, who will talk about vertical takeoff and landing airplanes.

The CHAIRMAN. I would like to ask you this. You refer to aeronautics and then in the same thought you refer to missiles. Do you consider missiles an aeronautical weapon, or is it an astronautical weapon?

Mr. ABBOTT. This is a difficult thing to answer. On one hand some people are quite sure that missiles in general do not belong in the space program. If this is true, I hope missiles won't fall between two stools. I think they should, then, be considered to be aeronautics.

The term "missiles" in general covers a great variety of things. There are, for instance, air-to-air missiles such as are used from one airplane to shoot down another, and these have wings. I think these are definitely aeronautical.

There are air-to-ground missiles such as the military are very much interested in for improving bombing capabilities of airplanes. There are ground-to-air missiles such as are used for defense—point defense—against aerial attack. Most of these missiles operate completely within the atmosphere and are winged; hence I think are closer to aeronautical.

Then of course there are the ballistic missiles which I fear are getting, in most people's minds, to encompass the whole word "missile" because of their tremendous importance. These missiles do go out into space. They go out into space much like a fish jumping out of water. They have a very short excursion into space. The problems encountered with these missiles are almost entirely problems that are encountered while they are in the atmosphere. It makes no difference to me whether they are called space vehicles or whether they are called aeronautics. It makes a great deal of difference to me that they get the attention that they should have in one place or the other.

The CHAIRMAN. I understand that. However, most of the witnesses—in fact, all of the witnesses we had questioned about it—had said that a missile was a space weapon. I had assumed, because a missile doesn't rely upon the atmosphere but relies rather upon a different type of propulsion to move, which is not a part of the atmosphere, that it was a space weapon.

Mr. ABBOTT. I would have no quarrel with that whatsoever, particularly as applied to the ballistic missile. My use of the term "missile" in this connection, however, was supposed to be a general one covering all types of missiles.

Would you, for instance, call a missile which is fired from an F–104 airplane at a target, another airplane in the air, and which depends for its sustenance on wings which it carries, as being a space vehicle,

The CHAIRMAN. Of course I am not to answer the question. You are the expert.

Mr. ABBOTT. I would not.

The CHAIRMAN. You are the expert, but nonetheless, others have indicated that the test was the type of propulsion rather than whether or not it might have some semblance of a wingspread.

Mr. ABBOTT. I am afraid I would have to quarrel with that because, for instance, all our research airplanes since 1946 which are very definitely airplanes have used rocket propulsion which is the same type of propulsion used in these missiles.

In fact they have used liquid rocket propulsion. This has also been true of a number of aircraft in other countries as well as in this country.

The CHAIRMAN. Your test would be——

Mr. ABBOTT. My test would be whether it flies in the atmosphere or not.

The CHAIRMAN. And whether it uses wings and whether it doesn't. Really that is what it is isn't it?

Mr. ABBOTT. Yes. That is reasonable.

Mr. FULTON. How about a balloon?

Mr. ABBOTT. I myself would not think that a balloon would be a space craft.

Mr. FULTON. It doesn't use wings.

The CHAIRMAN. It certainly wouldn't be a space craft though.

Mr. ABBOTT. I am sorry to have used words which caused this sort of a discussion because I think it is a little fruitless as to how one classifies these things.

Mr. FULTON. That is the point of my question.

The CHAIRMAN. It might not be fruitless to this committee. It may be very vital because of jurisdictional matters.

At any rate your next witness is Mr. John P. Campbell?

Mr. ABBOTT. Yes.

Mr. FULTON. Before you leave, with the Chairman's permission, on the difference between a supersonic plane and a hypersonic plane, I would like to pinpoint what the changeover is, for example, from the X–1–A plane with 2.5 mach, to a supersonic plane; and likewise the X–2, with a mach 3 speed, to a supersonic plane.

But if we come to the X–15 now, what is that—hypersonic?

Mr. ABBOTT. The X–15 is commonly referred to as hypersonic.

Mr. FULTON. So that is the beginning of the hypersonic airplane.

Mr. ABBOTT. Yes, I think this is correct. I must say that I sympathize with you a great deal about this terminology. I myself regret that it ever arose. However, this is something that arises in a spontaneous manner among a great many people. And any one individual or group is helpless to do anything about it.

Mr. FULTON. The trouble with you people is you name things like the doctors and the biologists and the zoologists do, and it leaves us common people out of it.

Mr. ABBOTT. I am afraid this is true.

The CHAIRMAN. Any further questions?

Mr. ABBOTT. I plead guilty.

Mr. MILLER. Like Topsy, don't the names just grow?

Mr. ABBOTT. This is correct, they just grow.

The CHAIRMAN. Mr. John John P. Campbell on vertical takeoff and landing aircraft.

STATEMENT OF JOHN P. CAMPBELL

Mr. CAMPBELL. Gentlemen, I am going to give you a brief survey of the work that is going on in the field of vertical takeoff and landing aircraft, with particular emphasis on NASA research and its relation to service interests in this field.

First I would like to bring out a few points regarding these aircraft in general. Vertical takeoff and landing—or VTOL aircraft as they are usually called—is one that takes off vertically; changes from hovering to forward flight; cruises to its destination; and then performs a transition back to hovering and lands vertically.

These aircraft can take many different forms, as you will see later; but it is possible to group them into five basic types according to their means of propulsion.

These types are shown on this chart listed in order to their top speed capability, with rotor type at the low speed end; rocket types at the high speed end; and with propeller, ducted fan, and turbojet types in between.

For this presentation I am going to narrow the field down a bit at each end of the speed range. Under rotors, I am going to exclude the helicopter because the helicopter is a well-developed VTOL type that actually constitutes a large separate field of VTOL aircraft in itself.

At the high-speed end I am going to exclude the rocket-powered space craft which will take off vertically and perform a soft vertical landing on the moon or one of the planets, for this type of machine has been covered in other presentations.

This discussion, then, will be concerned with propeller, ducted fan, and turbojet VTOL aircraft, and with some of the rotor aircraft other than the helicopter. Before we get into a discussion of these various types, let us examine briefly the reasons for the recent increase in interest in VTOL airplanes.

Actually there has been a certain amount of interest in airplanes of this type for many years because of the obvious advantages such a machine would afford. But it was not until about 10 years ago that designers started giving such airplanes serious consideration. Two of the primary factors responsible for this new and more serious look at the VTOL airplane were the development of the turboprops and turbojet engines, and the success of the helicopter.

The significance of the new engine developments is shown on this next chart, where we have the engine weight in pounds per horsepower shown for the automobile piston engine, the airplane piston engine, and the turboprop engine.

The airplane piston engine, which weighs about 1 pound per horsepower, might be considered a lightweight engine, since it weights only about one-third as much as an automobile piston engine of equal power. But this engine is still too heavy for use in a VTOL airplane, which inherently requires a very light engine.

The turboprop engine, on the other hand, weighs about one-half as much as the airplane piston engine, so it is very well suited to use in a VTOL airplane and its development in the mid-1940's brought about a greatly increased interest in these airplanes.

This second important stimulus to work on the VTOL airplane was the success of the helicopter, which demonstrated the great usefulness of vertical takeoff and landing capability, both for military operations such as those in Korea and for certain commercial operations. Actually it has been not only the success but also the basic problems and limitations of the helicopter that have spurred interest in the VTOL airplane.

These helicopter problems include high maintenance costs and mechanical complexity, and a very limited top speed.

The helicopter is basically a hovering machine and in forward flight it turns out to be much less efficient than a conventional airplane.

One logical approach toward minimizing these problems of the helicopter is to design a machine that is essentially a conventional airplane with vertical takeoff and landing capability added. This is the VTOL airplane.

Now, let's take a look at the VTOL types of current interest, considering first the interests of the military services, since a large part of the work to date in this field has been sponsored by the services with military uses in mind. First we will consider the interests of the Army.

The Army is very much interested in VTOL aircraft as a means of increasing its mobility in the frontline combat areas. They point out that despite the improvements in ground mobility, the average speed in combat is now only about 3½ miles per hour, or only about 1 mile per hour faster than in the days of the Roman legions.

Three of the classes of VTOL aircraft they are interested in are transports, combat surveillance aircraft, and the aerial jeep. One transport machine they are interested in would be a machine with a payload of 2 to 4 tons, an operating radius of about 250 miles, and a cruising speed of about 300 miles per hour. It should be a combination VTOL–STOL machine. That is, it should be capable of both vertical takeoff and landing and short takeoff and landing from runways when it is overloaded.

The combat surveillance aircraft could be a small machine capable of flying at subsonic speeds.

The aerial jeep is, as the name suggests, a machine that can do in the air what the ground jeep does on the ground. It can have a top speed less than 100 miles per hour, but it should be simple and easy to fly, and should be suited to flying at very low altitudes or in the nap of the earth, as the Army people put it.

One interest of the Air Force and the Navy has been in jet VTOL interceptors and fighter-bombers that could operate either from shipboard or from unprepared bases near the front lines or in areas where it was not desirable to build landing fields. Their interest in transport airplanes is similar to that of the Army, and VTOL transports would be essential for supporting these VTOL interceptors and fighter-bombers that operate from unprepared bases.

There is another aircraft of interest to the services that might be considered a VTOL aircraft. It is the ground effect machine which was covered before this committee, I believe, last week.

Since the possible applications of such a machine were probably covered very well at that time, I will only point out here that the NASA is conducting research with models of this type, and in fact we did some of the basic research leading to this concept about 5 years ago.

Included in our research at present on this concept are studies of the operation of these ground effect machines over water and over rough terrain.

Mr. FULTON. On that point, what height and speed differentiates the Army from the Air Force and the Navy type aircraft?

Mr. CAMPBELL. So far I believe it has been mainly one of size, limitation on the size, that the Army can operate. In that regard I think

some of the work for the Army has been done by the Navy and Air Force. Actually they are not interested in high-speed aircraft at all. They are mostly interested in the transport types and machines like the aerial jeep.

This reconnaissance airplane I mentioned might be able to fly at high supersonic speeds. Actually they are thinking at present of only 250 or 300 knots.

In this research I mentioned on the ground effect machines, there has been a close relationship between the work of the NASA and the service interests. This has been true of virtually all our work in this VTOL aircraft field.

In some cases we have done the basic and exploratory research which has resulted in ideas for promising new VTOL types. This information has been brought to the attention of the services.

Later, at the request of the services, we have done the applied research required in developing these specific VTOL aircraft. A good example of the relationship between NASA and the services in this work has been the work done in connection with the turboprop VTOL transport. Some of this work is covered on the next two charts.

We show on this chart some of the models used in the research on the VTOL transport starting about 8 years ago. These two models on the left are called deflected slipstream configurations because they have large flaps for deflecting the propeller slipstream downward to provide the vertical lift for hovering flight.

In general our research has indicated these are not very promising machines for vertical takeoff and landing operations because of the thrust loss incurred in turning the propeller slipstream downward, but they are promising types for short takeoff and landing or STOL operation.

This model at the upper right is a tilt-wing configuration——

Mr. FULTON. STOL?

Mr. CAMPBELL. Short takeoff and landing. This model here is a tilt-wing type. The wing and the propellers are in the position shown here for vertical takeoff and landing, and they rotate down to the normal position for cruising flight. This is a good configuration for vertical takeoff and landing, but it is not as good for short takeoff and landing as the models with the large flaps.

This model at the lower right is a combination VTOL–STOL machine—that is, capable of both vertical takeoff and landing and short takeoff and landing. It has a tilt-wing with a moderate size flap that is deflected in low-speed flight.

It combines the best features of these other configurations and appears to be a very promising VTOL–STOL type.

The work that we have done with these and other similar research models has led to the construction of the three VTOL research airplanes shown here on this next chart. These research airplanes have been sponsored and financed by the military services for the purpose of obtaining preliminary information on VTOL airplane flying qualities. Research airplanes such as this are sometimes called flying test beds because they are simple and usually crude looking machines that are intended only for research.

Since they are relatively inexpensive compared to operational prototypes of military aircraft, they afford the services an economical means of obtaining flight research data on VTOL aircraft. The two

machines at the top here are the Vertol tilt-wing airplane and the Ryan deflected slipstream airplane, both sponsored jointly by the Army and Navy. The configuration at the bottom is the Hiller X–18 tilt-wing configuration sponsored by the Air Force.

We have worked closely with the military services and industry in the design and development of these machines, and at present we are assisting in the preliminary flight testing of the Vertol and Ryan machines. Later NASA will obtain these machines for use in flight research programs.

All of this work that has been done with models and with these flying test beds is leading toward the development of what we feel is probably one of the most promising VTOL types—the propeller VTOL transport. In addition to the military interest in such an airplane, there is also an increasing interest in commercial applications of this type. One possible operation of such a machine is from a heliport located on a platform near the center of a city, as indicated on this chart.

Since a VTOL transport of this type could have a cruising speed comparable with that of conventional turboprop transports and could still operate from close-in airports such as this, it could obviously afford a large saving in the time required to travel from city center to city center. A machine of this type, however, will cost more to build and operate than a conventional transport, since for the same passenger capacity it will be about 25 percent heavier and will probably require about twice as much power as the conventional transport. It requires very large amounts of power for this vertical takeoff and landing operation.

Mr. McDonough. You use the propeller there on the tilt-wing to go up and then you put it on a level for forward flight?

Mr. Campbell. That's right; and the power requirement is actually for the vertical takeoff and landing operation. In forward flight you really don't need all this power.

Mr. McDonough. You mean the engine to take off takes more power than it does in forward flight?

Mr. Campbell. That's right, about twice as much is necessary; and that makes the airplanes, of course, more expensive and heavier.

Mr. Fulton. On your previous model you had a pusher type. That seems to be the ordinary conventional type with the engines along the leading edge of the wing. Are you trying both? On one other model you have a pusher type.

Mr. Campbell. I don't believe we have one.

Mr. Fulton. May we see the other one?

Mr. Campbell. This one right here?

Mr. Fulton. The bottom righthand one.

Mr. Campbell. That is still a tractor arrangement. In fact, this is very similar to the arrangement——

Mr. Fulton. But when it comes down it tilts toward the front?

Mr. Campbell. It is still a tractor arrangement.

Mr. Fulton. It doesn't tilt back?

Mr. Campbell. That's right; the wing tilts down like this. It might be confusing here because it is pivoting around the trailing edge. This one you notice up here is pivoting around the leading edge, but they both tilt in the same direction. It is the same configuration.

Mr. BASS. Mr. Chairman?

The CHAIRMAN. Mr. Bass.

Mr. BASS. I would like to ask you this question. You mentioned the so-called ground effect machine.

Mr. CAMPBELL. Yes, sir.

Mr. BASS. We received a briefing last week on that. I was much impressed. It seemed to me that type of propulsion and machine was so much more efficient and less clumsy than this that I wonder why you have spent so much money on this sort of a system.

Mr. CAMPBELL. That machine is very limited in its application. It has to operate very near the ground. It is able to operate efficiently in hovering flight near the ground because of this ground cushion that is provided underneath.

But when you start considering the operation of the machine, I think you will find that there are many operations in which you couldn't use such a machine. You would be forced to fly at altitude.

Mr. BASS. This is really employing the so-called brute force method.

Mr. CAMPBELL. I think you will find this ground effect machine—as I say, as long as you are content to stay a few feet off the ground you can use it. It admittedly is more efficient than these other types in hovering flight under those conditions. But I think the answer is that there is a definite limitation in the operational capabilities of machines of that type.

Of course it remains to be seen in the future in actually using these machines just what type of uses each type will fit in for.

Mr. BASS. Except for that limitation, then I gather you feel you would agree it would be——

Mr. CAMPBELL. That's right. We are studying that machine, too, but we are studying it more in competition with ground vehicles actually than in competition with aircraft.

Mr. ABBOTT. If I might interject something here about this limitation, it is very probable that this ground effect type machine will prove very useful for some applications. For instance, the Army may have excellent applications for such a machine. Any time that you have terrain which is just reasonably flat, you could use it. But if we take a situation like the one shown on this chart, for instance, where you might have a heliport in the middle of a city, one could scarcely depend upon using either the streets or the rooftops of buildings to supply continuous support for such a machine. You have to have one flying on its own once it is off the ground. Similarly, a ground support machine will not, it appears now, answer all the requirements of the Army.

For instance, there will be a great deal of terrain for which this would be unsuited. Imagine its usefulness, for instance, or lack of usefulness, in a very mountainous terrain cut with cliffs and sharp canyons or anything of that sort. It would have to follow contours of the ground in general.

For instance, if it went over a cliff, it would just be off over a cliff like any ground vehicle. So I think it is a matter of varied usefulness for various types of vehicles. They all have their place and we are working on all of them.

Mr. CAMPBELL. I am going to shift the subject a little here now from the propeller type to cover briefly the rotor, ducted fan, and

turbojet types I mentioned earlier. We have done the same general type of basic and applied research on these other types that we have done on the propeller machines, but I am not going into that research at all. Instead, I am just going to show you some of the configurations that are under study.

First we have here three rotor machines. At the upper left is the McDonnell XV–1 which has a rotor for hovering flight and a pusher propeller for forward flight. It is shown here mounted in the Ames Research Center 40- by 80-foot wind tunnel for force tests. The machine at the bottom is the Bell XV–3, a tilting rotor configuration. The rotors are in the position shown here for takeoff and landing and, for performing the transition to forward flight, the rotor shafts tilt downward so that the rotors serve as propellers.

This machine at the right is the Delackner Aerocycle, a flying platform machine which the pilot controls just by leaning in the direction in which he desires to go.

Here we have three ducted fan machines. A ducted fan might be considered simply a propeller with a ring or shroud around it. The machine at the upper left here is the Doak tilting duct machine which has tilting ducted fans at each wing tip. It is another service-sponsored flying test bed that the NASA is working on.

At the lower left is an aerial jeep which I mentioned earlier as being a machine the Army is very much interested in. This is an early version of the Piasecki aerial jeep. The machine at the right is the Hiller flying platform which is flown in the same maner as the Delackner Aerocycle I showed earlier—that is, the pilot just leans in the direction he desires to go in.

The principal advantage claimed for these ducted fan machines over machines with unshrouded propellers is that they afford you more thrust with the same amount of power for a given propeller diameter; or another way to look at it, with a given amount of power and thrust, you can keep the propeller diameter smaller.

Also it is suggested that the shroud serves as a guard in cases such as machines like the aerial jeep and flying platform.

Whether these advantages outweigh the disadvantages of these ducted fans remains to be seen. Actually the ducted fan has the disadvantage of the additional weight and drag of this duct itself, and also it introduces several undesirable stability characteristics.

Mr. FULTON. With the chairman's permission, what is the ton-mile cost or saving compared to other types of air transport in those particular types of vehicles?

Mr. CAMPBELL. Actually, the very brief studies that have been made on that subject—we have done very little along that line, but the indication is that a machine with tilting ducts like this came out very similar in cruising performance to a propeller-driven configuration. But this machine here would not be nearly as well suited for short takeoff and landing operations or for performing the transition to forward flight because the slipstream is not acting over the wing. In other words, in the case with the propellers on the leading edge of the wing, the wing is bathed in the slipstream and produces higher lift.

So with the propellers it is a more efficient machine for short takeoff and landing.

This looks to us right now mainly to have the advantages of compactness and for certain special applications it might be the best thing. But it does really remain to be seen whether this ducted fan is going to be used in any case in place of an unshrouded propeller.

On this last chart I have three turbojet machines. At the upper left is the Ryan X–13, which has a clip on the nose. It engages a cable on this landing service trailer for vertical takeoff and landing. To perform the transition to forward flight, the whole machine tilts forward to a horizontal attitude.

From operational considerations, the services now seem to prefer configurations where the fuselage remains horizontal, like the Bell X–14 at the upper right. This X–14 has two jet engines in the forward part of the fuselage, with some vanes in the tailpipe beneath the wing here to deflect the jet exhaust downward to provide the vertical lift for hovering flight.

When Bell completes its preliminary flight testing of the X–14, it is going to be turned over to the NASA for another flight research program.

At the lower left here is a model of the Bell XF–109, a Mach 2 interceptor fighter-bomber configuration, which, incidentally, has recently been canceled. It had two jet engines in tiltable pods at each wing tip, shown here in position for hovering flight. It also had two more jet engines in the nose of the fuselage and two more at the tail to help provide the vertical lift for hovering flight.

Mr. FULTON. Canceled by whom?

Mr. CAMPBELL. The Air Force and Navy.

Mr. FULTON. Why?

Mr. CAMPBELL. Apparently, as I gather—this is all indirect; I don't have the direct information—but they had to choose between this and other things as far as—decide on where to use their funds. I gathered the other day they are still interested in this type.

Mr. FULTON. It was a budgetary consideration and not a scientific——

Mr. CAMPBELL. I gather, because right now we don't know of any reason why machines of this type cannot be developed. The state of the art is such that machines of this type probably can be developed if there is a need—strong enough need.

Mr. FULTON. Do you recommend as a scientist that the program be continued?

Mr. CAMPBELL. I don't believe I am really in a position to say. We think that one could be built, but I think it is really up to the services to decide whether they need one or not, or bad enough to use the money on this.

Mr. FULTON. Leaving the weapons system out of it, do you as a scientist, and with no budgetary elements in your judgment, recommend that such a research program be continued?

Mr. CAMPBELL. Actually this was not a research program. I do think some research should be done along this line. It is being done with the X–14. I do think that in the future they will probably build the other turbojet VTOL machines that should be studied. I am not really in a position to say whether this particular machine should be continued or not.

Mr. FULTON. I would like to have at this point in the record, with the chairman's permission, the recommendation of the Agency on whether from a scientific point of view further study should be made, and also the size of the VTOL and turbojets.

Mr. ABBOTT. Mr. Chairman, I think the position of the Agency is clear on this. We do believe that further work should be conducted on vertical takeoff and landing aircraft. However, when it comes to a matter of telling the military services how they should spend their money for a particular machine which is not designed as a research airplane, but as a weapons system, I think this is entirely outside of the responsibility of this Agency.

Mr. FULTON. Thank you.

The CHAIRMAN. All right, sir.

Mr. CAMPBELL. This last configuration here shown at the lower right is an artist's drawing of a more or less futuristic configuration we are studying in some exploratory research at this time. It represents a mach 3 VTOL transport with its main propulsion engines in tiltable pods out here at the wing tip. It is shown here in the position for takeoff and landing.

It also has a large number of small jet engines mounted vertically in the fuselage and used only for takeoff and landing. When we consider the problems involved in developing a conventional mach 3 transport airplane and then include the problems involved in developing this vertical takeoff and landing feature, it is apparent that machines of this type are still a long way off.

In conclusion I might point out that, although the research to date has indicated many promising military and commercial applications of VTOL aircraft, there still remains much work to be done before we have practical operational machines of this type.

The CHAIRMAN. Thank you very much, sir.

Mr. MILLER. When was the first vertical machine put together, and where was it flown? Did the Navy fly one?

Mr. CAMPBELL. The Convair XFY–1 was flown back in 1954, I believe. The work on that machine was started back in about 1949. We started it at Langley Field, working with the Navy on that configuration about 10 years ago.

Mr. MILLER. Where was it actually flown?

Mr. CAMPBELL. It was flown first at Moffett Field in a hangar. Later on, I believe at Brown Field in San Diego.

Mr. ABBOTT. This was perhaps the first vertical takeoff and landing airplane. Of course if we talk about the first craft of any type able to take off vertically, I would be unable to say when it was. This would go back to the early days of the helicopters.

The CHAIRMAN. If there are no further questions, the next witness is Herbert A. Wilson, Aircraft-Supersonic and Hypersonic. I might say this, too, that we have two witnesses on this same general subject—Mr. Anderson, Rodger Anderson who follows, who will talk on the structures for hypersonic vehicles. Do we have both of them present?

Mr. ABBOTT. Mr. Chairman, there has been some change in the program since you got that copy. We have Mr. Wilson who will talk on some of the problems of supersonic aircraft. Mr. Drake, who will talk on the X–15 airplane, and piloting and control problems, and

instead of Mr. Anderson, Mr. Heldenfels of our Langley Research Center, who will talk about structures for hypersonic vehicles, and something about the problems of structures for space craft.

Then, providing he gets here in time, he is now on an airplane, Mr. Ames, who will talk about some of the research problems of missiles.

I think it would be well to take them in the order that I have just stated, rather than in the order which you have there, if this is agreeable to you.

The CHAIRMAN. Surely.

Mr. ABBOTT. Also, all these talks in this section from now on—that is, those of Messrs. Wilson, Drake, Heldenfels, and Ames—necessarily are classified because in order to make these talks meaningful we must, I think, talk about military weapon systems which are classified by the military services.

The CHAIRMAN. Why not then hear from Mr. Wilson. Is his talk classified?

Mr. ABBOTT. Yes, his talk is classified.

The CHAIRMAN. What about Mr. Abbott? We have you down again here for construction and equipment.

Mr. ABBOTT. I am going to talk about the construction and equipment at the research centers. If you wish to take this up now, I would be very happy to do that.

The CHAIRMAN. That is in open session?

Mr. ABBOTT. That is in open session.

The CHAIRMAN. I think it would be preferable if we had all the open session at one time.

Mr. ABBOTT. We would be very happy to do that.

The CHAIRMAN. Suppose then we proceed with your statement. I would think that we would take up Mr. Wilson, Mr. Heldenfels, Mr. Drake, and Mr. Ames probably at one time because they all deal with the same general subject matter.

Mr. ABBOTT. That is quite satisfactory.

The CHAIRMAN. When we have finished with Mr. Abbott, the rest of the testimony will be classified.

STATEMENT OF IRA H. ABBOTT

Mr. ABBOTT. Mr. Chairman, this morning you heard about some of the construction items that are listed on page 323 of the budget book which is before you. I would like to talk about the budget items for construction and equipment at the Langley Research Center, the Ames Research Center, the Lewis Research Center, and the High Speed Flight Station which are listed on page 322 of the book and the top group of items on page 323.

These items are listed on this chart, together with the amount of money being requested for this purpose which totals $20,800,000.

You have been hearing about our programs and plans concerning aeronautical and space research, and you will hear more about these plans in the talks which will follow. You have also heard something about the major technological problems that must be solved to make these plans a reality, and also about the research information needed for the successful development of military aircraft, missile weapons systems, and space craft.

These programs must be supported by adequate research facilities. It is especially vital in these times when the state of the art is growing explosively, and rapidly changing direction, that we anticipate our research facility needs well in advance and press their construction as rapidly as possible.

Let us take a businesslike point of view for a moment and consider the sum that we are requesting for construction, $20,800,000, in relation to the total capital investment at these research centers which is now approximately $400 million. This amount represents about 5 percent of the total capital investment, and would replace these facilities in a 20-year period, not making any allowance for the greatly increased construction costs since most of the facilities at these stations were built.

We have a large number of items here. I should like to take time to discuss four of the large items: the ion and plasma jet facility, $6 million, for the Lewis Research Center; mass transfer cooling and aerodynamic facility at $4,050,000 for the Ames Research Center; data reduction center, at $2,505,000, also for Ames; and the analytical computing equipment at $2,645,000 at the Langley Research Center.

These are the large items. The sum of these items is approximately three-quarters of the total cost, the remainder being distributed among comparatively small items.

Let us turn then to this first item, the ion and plasma jet facility for the Lewis Research Center. Mr. Rothrock in his talk on space propulsion yesterday, I believe it was, told you something about the propulsion problems with which we are faced. Also some of you may have seen a fairly recent Walt Disney film on space travel which pictures an expedition to Mars by a fleet of rather strange umbrella-shaped craft, which are propelled by ion rockets. This film, insofar as the propulsion system is concerned, may prove to have a considerable amount of reality to it. Great interest has grown up in these electrical space propulsion systems, which include ion rockets as one of several possible types. Mr. Rothrock told you about this interest yesterday, which comes about because of the very small amount of propellant which is required to produce thrust for these rockets, and hence the capability that this type of propulsion has for continuous propulsion over a very long period of time.

Although this type of powerplant, as Mr. Rothrock said, is not suited for use in boosters requiring large amounts of thrust, they are very attractive for use in space flight for such missions as very deep space probes and interplanetary travel. The successful development of these devices would permit the accomplishment of space missions which would otherwise be very difficult and perhaps even impossible.

I have on this next chart a very simplified diagram of one type of electrical propulsion system, an ion rocket. This type of device is essentially a particle accelerator. Like other types of particle accelerators it operates in a vacuum which, of course, is its natural environment in space. Here we have a propellant coming in and being evaporated.

This propellant might be some such material as cesium, which was mentioned yesterday by Mr. Rothrock. Supposing, for instance, this cesium were evaporated here and then the cesium vapor, in being passed over these grids which are heated, becomes ionized— that is,

each molecule of cesium loses an electron and the resulting ions are accelerated out into this stream by these accelerating electrodes. The resulting electrons are pumped by an electric generator out here to electron guns and also mixed in this stream.

This very high speed stream flowing out in this direction produces a thrust forward like any other rocket, the difference being the very small amount of propellant used per pound of thrust per second in this rocket as compared with the other types. This, in turn, results from the very high velocity of these particles as discussed by Mr. Rothrock.

For the last 2 years or so a considerable amount of work on propulsion systems of this type has been done, both theoretically and with small bench-sized apparatus that could easily, for instance, fit on this table. This is all very well, and is important work. However, before such rockets as this can be used in flight, there is a tremendous research and development problem that has to be undertaken which cannot be done on these small bench-sized objects.

Full-sized rockets will have to be tested, and they will have to be tested under conditions which will permit their continuous operation for long periods of time to assure their reliability. In interplanetary or deep space flight these rockets may be required to operate for very long periods of time—months or eventually perhaps even years, with complete reliability.

The difficulty in making such tests, either research or development tests, lies in the fact that these devices work only in a vacuum. Consequently we have to have some facility for duplicating here on the surface of the earth the conditions existing in space as far as the vacuum is concerned.

Mr. McDonough. You can't do that, can you?

Mr. Abbott. We can't do it completely. We think we can do it well enough, however.

Mr. Miller. Will this throw off any radioactive material?

Mr. Abbott. No.

Mr. McDonough. Do you find any other element besides cesium that can be reacted in the same manner?

Mr. Abbott. Oh, yes.

Mr. McDonough. What?

Mr. Abbott. Any of the alkali metals are suitable for this. Cesium happens to have a very weak attachment of an electron to itself, so it is ionized easily. So it happens to be attractive. I used it for an example, but this is only one example.

Also we do not have to stick to the ion type of rocket. There are also plasma rockets in which a great many things can be used, including hydrogen, for instance.

Mr. McDonough. Will the particle expulsion at the rear end, plus the heat, give you the forward motion?

Mr. Abbott. The thing that gives you the forward motion is the acceleration of the particles. If you want to go that way, you push something else this way.

The faster you push it this way, the smaller amount of material you have to push on, hence the smaller the amount of material that you have to carry to throw away. However, unfortunately, the faster you push it this way, the more energy you are putting into it, hence the

larger the powerplant you have to carry to provide that energy, as Mr. Rothrock mentioned yesterday.

Mr. McDonough. Have you actually done that procedure?

Mr. Abbott. Yes, this has been done with small, bench-sized apparatus using cesium, and it does work on a small scale.

Mr. Fulton. Would you tell us further of the operation of the so-called electron gun? That term has in it the possible idea of an explosion or of a propulsive power. We can see how the ionization works. Would you tell us now on the electrons how they are discharged?

Mr. Abbott. Yes. Again I fear I am going to have to apologize for this unfortunate terminology which has grown up in the industry, in this case not in the aeronautical industry, but in the electronic industry.

The most common example of an electron gun I know of—and the term is universally used among the electronics people—is the back end of television tubes. The television tube consists primarily of an electron gun which sends a stream of electrons forward into the tube. This stream is then focused into a narrow pencil which hits on the phosphor on the front of the tube and excites a spot of light. This spot is then made to trace back and forth across the front of the tube to produce a picture. This apparatus in the back end of a television tube is known as an electron gun, and I have used the same terminology here.

Mr. Fulton. What, then, do the electrons do that the ions do not?

Mr. Abbott. The electrons, of course, provide very little propulsion because of their extremely small weight. However, if we expel the ions and no not expel the electrons, the whole vehicle would very rapidly pick up a high electrical charge which would make it impossible to expel the ions. Consequently the only——

Mr. Fulton. So really what the electrons are doing are not for propulsion purposes, but they are rather to get rid of the electrical charge that builds up?

Mr. Abbott. Yes, that is correct.

Mr. Miller. While you are doing that you take advantage of the little energy you can get out?

Mr. Abbott. Yes. It is trifling.

The Chairman. And you give it a separate exhaust?

Mr. Abbott. You give it a separate exhaust in the case of the ion rocket and you mix it with the ions in this stream as rapidly as possible in order to cut down the space charge back here.

The Chairman. Then you create electricity after it has left the missile?

Mr. Abbott. I am afraid not, sir. I think the only electricity that is in this circuit is here [indicating], because these electrons will then combine with the ions to produce neutral particles again in space.

Mr. Fulton. When it moves up from the ionization grid into the electric generator, what type of a current is it?

Mr. Abbott. This is a direct current. The electric generator, of course, is merely a pump for electrons. This is a direct-current generator which takes these electrons from the ion grid over into this device that I have called the electron guns where they are expelled.

Mr. Fulton. That is one of the points of my question. When you have it heated where it obviously is with the ionization grid, and then

the electrons will move away from the heat and over into the cooler portion of the cells, actually your electric generator is then just accelerating that natural movement or circulation, isn't it?

Mr. ABBOTT. Yes; it is. It is increasing the potential here and providing the potential that is needed in an electron gun to discharge into space.

Mr. FULTON. So the generator is really clearing the electric charge out of the vehicle rather than generating a current?

Mr. ABBOTT. That is correct.

Mr. FULTON. Thank you.

The CHAIRMAN. Could I ask you a question or two?

Mr. ABBOTT. Certainly.

The CHAIRMAN. You refer to the use of cesium in that type of equipment. You said other metals could be used, too. What are they?

Mr. ABBOTT. Magnesium, potassium, sodium. It is not limited——

Mr. FULTON. Couldn't you get ordinary salt?

Mr. ABBOTT. Sodium could be used. I do not mean to imply that the propellant is limited to these things. These things merely happen to be the ones which are most convenient to experiment with.

The CHAIRMAN. I wanted some others. I have got them.

How large a piece of cesium would you need to operate that sort of machine over a period of time?

Mr. ABBOTT. This depends entirely on the potentials at which it is operated. I do not remember offhand, but something like a pound of cesium per pound of thrust per day, or something like that, is in the right ballpark.

The CHAIRMAN. If you are gone a year, then, on that trip, you would need 365 pounds of cesium?

Mr. ABBOTT. Something like that—per pound of thrust.

The CHAIRMAN. That would depend on how many pounds of thrust you have, then?

Mr. ABBOTT. Yes.

Mr. MCDONOUGH. What about a cooling system around there? You are creating a lot of heat.

Mr. ABBOTT. There is nothing here that requires cooling. This actually is heated—on this diagram it is indicated that it is heated by electricity. This could be heated by anything to evaporate the cesium and keep these grids hot. Other than that, this rocket does not run hot. These accelerating electrodes are at high electrical potential, but are not hot.

Mr. MCDONOUGH. You mean the exhaust is not hot either?

Mr. ABBOTT. Not very hot, no. Only in the sense that it is traveling fast. If you stopped it, energy would be released as heat.

Mr. FULTON. What is your specific impulse on it? Is it a high specific impulse?

Mr. ABBOTT. It is a tremendously high impulse. I don't have the values in mind. Mr. Rothrock mentioned some of them yesterday. They run into many thousands.

Mr. WOLF. What would be the relative cost of this cesium? Do you have any idea?

Mr. ABBOTT. The cost of the cesium for this would be completely negligible. No, I am sorry, I do not have any figure on the cost of

cesium, but the cost of the cesium compared with the cost of this whole piece of apparatus, and the electrical powerplant it will take to run it and the uranium which would have to be used in the reactor which supplied the electricity—all this taken into account, the cost of the cesium would be negligible.

Mr. FULTON. Could you give us some proportion—for example, if we had a vehicle and load of 3,000 pounds in space, what kind of a thrust would we need and how would it build up in acceleration?

Mr. ABBOTT. In the first place, I doubt if devices of this sort would be used very extensively on space vehicles as small as 3,000 pounds. I am looking ahead to the larger units of the future. The figures which are commonly talked about today are in the neighborhood of 1 pound of thrust per thousand pounds of weight of the complete vehicle.

Mr. FULTON. That would then give it what acceleration?

Mr. ABBOTT. Quite small. This would be about one one-thousandth, you see, of the acceleration of gravity. However, when continued over a very long period of time of weeks or months, even such small accelerations build up tremendous velocities.

Mr. FULTON. So that would really be moving at about three one-hundredths of a foot per second to start with?

Mr. ABBOTT. Yes, the acceleration.

Mr. FULTON. The acceleration would be three one-hundredths of a foot per second to start with?

Mr. ABBOTT. I think I tried to make it clear, sir, units like this would not be suitable for boosters. We would have to put the vehicle in space with either conventional chemical boosters or a combination of chemical-nuclear boosters. Only when it was outside of the effective gravitational field of the earth—I realize I am using my words loosely here——

The CHAIRMAN. Even then you would not have a jackrabbit start, would you?

Mr. ABBOTT. You would not have a jackrabbit start. This is a long, slow accelerating process. However, it is the kind of thing we are going to need for very extensive space travel.

Mr. FULTON. Suppose you let it continuously accelerate for 200 years? What speeds would you get?

Mr. ABBOTT. I am sorry, sir, I have not figured that. If one let this thing accelerate long enough one would have to apply the Einstein theory to it.

Mr. DADDARIO. Have we developed the metals that would withstand the heat that this type of vehicle would generate?

Mr. ABBOTT. Once out in space there would be no special heating problem except from the radiant energy of the sun which can be taken care of quite easily by regulating the reflectivity of the surface. There is no air out there to generate heat through friction. The amount of gas out there is so small that the amount of heat generated is completely negligible.

These units themselves do not require high temperatures.

Mr. FULTON. How do you vaporize the cesium?

Mr. ABBOTT. We vaporize that by heat, but these temperatures are not high.

Mr. FULTON. What level; 2,000° to 5,000° C.?

Mr. ABBOTT. No more than that. I forget the vaporization point of cesium, but it is not a high temperature, less than 1,000° C.

Mr. FULTON. How do you get that heat?

Mr. ABBOTT. It could be obtained in any one of several ways. If we were using a nuclear reactor to power this, the heat might come either directly from the nuclear reactor or from the electrical energy. Either way.

The CHAIRMAN. Any further questions?

Mr. WOLF. Mr. Chairman, I was just wondering about how big have you experimented with the idea of solar batteries in correcting electrical energy for anything besides use for the radio controls and things of this kind?

Mr. ABBOTT. Solar batteries are very useful when the amount of power required is not very large—that is, when it is power which is used for radio communications, flashing lights, and this sort of thing. However, they do not appear to be sutiable when very large amounts of power such as are required for propulsion are needed. They are under considerable investigation, both by ourselves and by many people throughout the country.

As you know, they are being used today, operating satisfactorily on the Vanguard.

Mr. FULTON. My next question was along those lines. Why don't you use the heat of the sun to be concentrated through lenses into the propellant capsule to produce your desired heat? Wouldn't you get a tremendously hot——

Mr. ABBOTT. To heat the cesium?

Mr. FULTON. Yes.

Mr. ABBOTT. This of course could be done if the system were stabilized so that the heat of the sun could be focused there. This would be entirely possible. I would like to point out that one has to have a certain sense of proportion here. The amount of power required to heat this cesium in proportion to the total amount of power required to run this unit is perhaps equivalent to the power of a flea compared with the power of an elephant. Consequently it does not seem to be too important at the moment to worry about the exact source of this flea power.

Mr. MILLER. In other words, this at present is only schematic really?

Mr. ABBOTT. This diagram here is schematic.

Mr. MILLER. It is merely to show us——

Mr. ABBOTT. The power required to vaporize this thing is completely negligible.

The CHAIRMAN. How far off is this engine?

Mr. ABBOTT. I hope it is not very far off. As I say, we have run bench-sized objects.

The CHAIRMAN. On bench-sized objects, you don't move, do you? It stays in one place.

Mr. ABBOTT. No, it does not move. We measure the performance on it.

Mr. FULTON. On the question of thermal electric power, when we can change heat directly into electricity and you can discharge the spark, it has a push, doesn't it? If there is some way you can discharge the spark.

Mr. ABBOTT. There is only one way to get a push, and you are essentially correct. Mr. Rothrock went into this in some detail yesterday. You either push matter away from you or you can also do it by pushing photons, which is a form of energy which of course is also equivalent to matter.

The spark is composed of electrons. When the spark flows from one gap to another, what you really have is a flow of electrons. This heats the air in which you customarily see the spark, and you see this heated air primarily.

Now of course if one pushes out electrons, one does get some push the same as we do from here. The light that comes from the spark is photons, and of course if one emits photons, one also gets a certain amount of push.

The important thing here is that the faster this material moves backwards, the higher the specific impulse, and the less of it we have to throw away to get a given amount of thrust for a given period of time. There is a whole spectrum of methods in which we can do this. We can use in chemical rockets the products of combustion which move relatively slowly and require consequently a large amount of propellants per pound of thrust per unit of time.

We can in the next step go to such things as hydrogen heated by nuclear reactors, increase the speed of the exhaust, and require less material to be discarded per unit time per unit thrust.

We can then go to such things as ions, which go out at very much higher speed, but still at very low speeds compared with light, and get a higher specific impulse but at the expense of spending a higher energy.

We can then go to electrons which can be accelerated almost to the speed of light if you wish to put enough energy behind them. The amount of material goes down to a very small amount at the expense of a stupendous amount of energy which has to be generated on board the craft by a powerplant which will weigh something like 10 pounds per horsepower.

In the final analysis, we can go to light and throw out light itself at the speed of light; cut down the amount of material to the vanishing point, but increase correspondingly the amount of power required.

These are the choices.

Mr. FULTON. To answer my question, then, you are doing some experimenting on thermal electric means?

Mr. ABBOTT. We are, yes. We are doing some experimenting over this whole spectrum.

The CHAIRMAN. Regardless of what you are experimenting with, it is all based on the physical theory that action is equal to reaction?

Mr. ABBOTT. Yes, sir.

The CHAIRMAN. You are going to get a push forward by pushing backward.

Mr. ABBOTT. Yes, sir. Sir Isaac Newton stated this very well. The facility which we are requesting to test electric rockets is shown schematically in this diagram. It consists primarily of a very large tank which is a vacuum tank that can be pumped down to very low pressures in order to duplicate as best we may on earth the vacuum conditions existing in space in which these ion rockets or other types of

electrical rockets have to operate. In this case I have shown very schematically an ion rocket operating in this tank.

Now associated with this tank are the high vacuum pumps which are required to maintain the low pressures in this tank while the rocket is operating; such things as condensing baffles, and devices to sweep them, to condense out the exhaust products of the rocket in the tank so that we can operate the rocket continuously for long periods of time to see whether the reliability of the rocket is such as to permit its useful application to space.

The whole thing is located within a building with associated instrumentation. This item will cost $6 million, and we urgently request your favorable consideration of this facility, which we believe is badly needed.

Mr. McDonough. What is the maximum vacuum you can obtain through that?

Mr. Abbott. I am sorry, I don't have the figure before me. Maybe I do; let me look.

Yes, 10^{-9} atmospheres. That is one-billionth of atmosphere pressure.

Mr. McDonough. What elevation would that be?

Mr. Abbott. This is very, very high.

Mr. Fulton. About how high—150,000 to 200,000 feet?

Mr. Abbott. Oh, no; this would be up in the order of 200 miles or there about.

Mr. Fulton. Does the plasma in that plasma jet infer that it is superheated?

Mr. Abbott. I beg your pardon?

Mr. Fulton. Does the plasma phrase in plasma jet mean that it is superheated or just that it is dispersed?

Mr. Abbott. The word "plasma" is another piece of jargon for which we are not responsible in our field. This piece of jargon originated a long time ago among the physicists. It refers to a gas which is partially or wholly ionized, but which is electrically neutral—that is, it consists of ions and electrons in approximately the right proportions to be neutral.

Mr. Fulton. My point is, does it have the idea of heat in it?

Mr. Abbott. In order to maintain such a plasma without having the electrons immediately reunite with the ions, in which case it would no longer be a plasma, it is usually necessary for it to be extremely hot.

Mr. Fulton. So that it does have within it——

Mr. Abbott. It does have the connotation of very high temperatures, and plasma jets are very hot for this reason. The other important thing about the plasma jet is that plasma, being neutral, cannot be accelerated by simple electrodes. It is accelerated by other means such as a traveling impulse of a magnetic field which forces the plasma out, in one type of device, in much the same manner as you milk a cow.

I would like to turn next to this mass transfer cooling and aerodynamic facility for the Ames Research Center, at a price of $4,050,000. This is an example of the sort of thing we have been doing for several years to improve the capability of doing research in the

laboratory at speeds and temperatures duplicating those experienced in very high-speed flight, either by hypersonic aeronautical vehicles or by space vehicles returning to the earth through the atmosphere.

This has been a very difficult problem because of the very high temperatures that are involved. Typically the temperatures involved in such devices are much higher, if true simulation is to be obtained, than the vaporization point of any known material. If we go about this by ordinary methods, we also need to confine gases at very high pressures at these very high temperatures. You can see this is not an easy problem.

As we have progressed in our ability to do this sort of thing using small models, we have on several occasions requested from the Congress funds for the construction of the larger size equipment needed to do research. This mass transfer cooling aerodynamics facility which we are requesting for the Ames Center is an example of such a piece of equipment which we have needed for a long time, but which previously has been impossible to build.

This facility will permit us to do research under the realistic conditions of temperature and speed encountered in continuous flight up to speeds of about 12,000 miles an hour, and will permit us to do useful research in the laboratory at very much higher speeds on aerodynamic problems. It will also permit useful research on heating and heat transfer problems for conditions where the heat transfer is extremely high, such as those encountered by reentering ballistic missile warheads.

Mr. FULTON. With the chairman's permission, your gas dynamics, then, refers to the characteristics of turbulence and laminar flow rather than to combustible properties, doesn't it?

Mr. ABBOTT. It is beginning to be a general term applied to all the problems of flow of gases, whether at high or at low temperatures; but usually not involving such processes as combustion. What we are interested in here are the problems of the airflow on the external parts of very high-speed airplanes, missiles and spacecraft reentering the atmosphere.

The facility which is being requested is shown diagramatically here. It consists of this building which will house three jets designed for different purposes. One of the three jets is shown schematically here. This jet, with the associated piping, brings high-pressure air into this region here. This air is heated by being passed through electrical arcs in these electrical arc chambers.

Then the high-pressure air is expanded through this nozzle into the test chamber in much the same manner as any wind tunnel. It flows over the model and out through a diffuser into a vacuum tank, which is shown here.

We expect in these wind tunnels, if they can be called that, to reach speed in excess of 12,000 miles per hour and to reach temperatures on the order of 15,000° F. This is not an easy problem. We are just learning how to do this. This type of facility is very badly needed to give us the capability of studying flows at very high speeds and very high temperatures around models on the ground where they can be adequately instrumented without going to the expense of firing models through the atmosphere at these speeds every time we want to make a test.

Mr. McDONOUGH. Mr. Chairman?

The CHAIRMAN. Mr. McDonough.

Mr. McDONOUGH. Have we measured the temperature of reentry up to the present time?

Mr. ABBOTT. Yes. Temperatures have been measured by a number of people on reentering objects.

Mr. McDONOUGH. What temperatures have we encountered?

Mr. ABBOTT. The temperatures that are measured, of course, are the temperatures of the surface of the vehicles or of some material inside the vehicle, and not the temperature of the air which is impinging on the vehicle. That is why this temperature of 15,000° appears so high to you, I believe.

These vehicles are necessarily designed so that they don't burn up. This is done by any one of several ways, but no matter how it is done, the temperature is kept within the limitations of the material.

So, although the air temperature may be very high, it is unusual to measure temperatures higher than about 3,000° F., which is very high, and temperatures of about 2,000° F. would be much more in order.

However, these temperatures are produced by air striking the vehicle at temperatures which are very much higher, 15,000° or hotter; and this is what we must produce in the laboratory in order to understand these flows and the heat transfer process in order to obtain more efficient designs than we have today.

It is one thing to be able to design them so they don't burn up. It is another thing to get a really efficient design.

Mr. McDONOUGH. What material would you work with there to sustain 15,000°?

Mr. ABBOTT. Obviously there is no material which will sustain this temperature. Consequently one has to resort to trickery. There are various methods. For instance, simple cooling will do a great deal. However, there is a limitation to how much you can cool material. Even if you have a very thin piece of material and pass water at high speed and pressure behind it, there is still some limit at which it will burn up.

Another thing that one can do is to pass along the wall a cool layer of some such gas as helium, which helps to insulate the wall from the very hot gas. By combining such methods as these, we have confidence that we can reach temperatures on the order of 15,000°. This is why it has taken so long for us to learn how to design such apparatus. We have been looking into it now for several years.

To proceed, I would like to talk next about the data reduction center for the Ames Research Center at a cost of slightly over $2.5 million. In fiscal year 1958 we requested and received from the Congress a similar sum of money to construct a data reduction center at our Langley Research Center.

The needs for high-speed computing are both for data reduction and for the calculation of the very difficult and complicated theoretical problems with which we are now faced. These needs have been increasing at a very high rate. Our needs for computing facilities at the Ames Research Center are essentially the same as those at Langley, and we are now asking for the construction of this Ames data reduction center at this time.

This is essentially a building, as you see. It will provide the facilities required for the rapid processing of the research data and also for the solution of complex theoretical problems. It will be designed to house three existing digital computers which are now at the center; a new large capacity high-speed general purpose digital computer, which will be procured on a rental basis; and several special purpose analog and digital machines, some of which can be rented and some of which will have to be bought.

The center will also provide office space for the staff of professional people required to operate the computer facilities. The reason we need this building so badly now is that the presently available staff and computers at the Ames Research Center are housed in several small, cramped locations, including such places as basement rooms that were originally intended for storage; and in one case a balance room of a wind tunnel which is no longer in use. I think any of you who have seen those computer setups will realize this is a very unsatisfactory method for operating these computer facilities which require nicely air conditioned and clean environments.

We have been able to produce roughly satisfactory environments by installations of air-conditioning equipment and this sort of thing, but it is not really satisfactory. Moreover, this fragmentation of an operation over the large research center that requires close coordination, plus housing under these difficult working conditions, has created a situation which certainly is not conducive to the best results.

This requested building will house the present equipment and will provide space to permit the expansion that is now badly needed by rental of new equipment which we cannot accommodate at the present time because we simply have no place to put it.

I would now like to turn to the computational equipment for the Langley Research Center, which is shown here at something over $2,645,000.

The CHAIRMAN. Mr. Wolf.

Mr. WOLF. On this last data reduction center, is that strictly for the physical plant, $2.5 million?

Mr. ABBOTT. This is mostly for building. If you will wait just a moment, I can give you that breakdown. There is some equipment in it.

Mr. WOLF. Where is that? I couldn't find it in the book.

Mr. ABBOTT. It is listed on page 322, which also gives page references to more detailed breakdowns—this one is on page 337. On page 340 there is a detailed cost estimate which shows that of this sum, $1,260,000 is for the building; $660,000 is for a special purpose computer; a digital computer and analog-digital converter which has to be purchased because it is not obtainable on rental; $160,000 for the air conditioning of the building; $290,000 for electrical work, which also goes into the building. As you know, these computers require extensive electrical connections and duct work. Forty-five thousand dollars for streets, lighting, utilities; and $90,000 for design and engineering services.

So all except $660,000 of this, I think, is properly chargeable to the building and associated utilities.

Mr. WOLF. This is an estimated cost. How are you going to find somebody to build this? Is there going to be a bid proposition here?

Mr. ABBOTT. Yes, it will be a bid proposition. These estimated costs are based on a great many years of experience in making these estimates and we find that we hit them very closely.

Mr. WOLF. Is there only one company you can buy a computer from, or are those bid for, too?

Mr. ABBOTT. There are several companies from which the computers can be bought.

Mr. WOLF. Are these sealed bids or open bidding?

Mr. ABBOTT. It varies on things like computers. On things like buildings, it is invariably a sealed bid proposition. On computers, it might either be a sealed bid proposition or what is called a negotiated contract where negotiations are carried on with every competent supplier. This is because of the extreme difficulty of writing specifications in sufficient detail to produce what you exactly want in case of equipment of this sort, which is not off-the-shelf equipment. It usually has to be designed and built for the particular purpose involved. We do go to sealed bids wherever it is possible—this is the policy—and use negotiation only where necessary.

This item at the Langley Research Center is to procure computing equipment, both analog and digital, but primarily analog. The need for this equipment has resulted from an extremely large growth in the use of flight simulators in recent years. These flight simulators add very substantially to our knowledge about control of piloted high-speed airplanes, reentry vehicles, and automatic control and guidance of both these vehicles and of missiles. These simulators require computers capable of solving the complicated equations of motion at the same rate as would be experienced in actual flight using the actual vehicles which are being simulated. This requires large, high-speed computers.

In some cases they are of the digital variety, and in some cases the analog variety; and in some cases both types are used in combination.

Our present equipment is grossly inadequate for the problems we are now facing. I have some pictures here showing some of the existing equipment. This is a comparatively small analog computer equipment setup. In this case we are simulating conditions where we have on this breadboard some of the automatic control equipment which is actually used in the control of the vehicle. By bringing the control equipment into the system, we can simulate conditions using the actual characteristics of the control equipment which will be used.

This is another picture showing a simulator setup. We are here simulating a flight of a manned aircraft with the pilot sitting over here in a chair flying the airplane. The simulator simulates all the aerodynamic and propulsive characteristics of the airplane, and solves all the equations of motion as fast as the actual airplane itself would maneuver. The pilot sitting here flies it according to his instrument board, trying to perform a certain flight mission. The results come out over here on these plotting boards.

In this way, you see, it is possible merely by changing the setup in these computers to change the aerodynamic characteristics of the airplane and determine whether the pilot can then fly it better or not as well. This is a very elementary setup. The pilot in this case, you see, is sitting here in a fixed chair flying it from instruments which are in front of him.

This, incidentally, is called a fixed base simulator because the pilot's base is not moving. In other cases this chair is made to move to simulate the motions of the airplane. In some cases it might merely move in rotation about the three axes. In some cases it might move not only in rotation about the three axes, but up and down so that the pilot feels much of the motion of the airplane. This motion often has an important effect on his ability to pilot the airplane.

In another case, by the use of the Navy centrifuge at Johnsville, Pa., the pilot flies in the cab of a centrifuge. The point I am trying to make here is that these simulation equipments in which the pilot is involved, and, in some cases, simulation equipment which involves the automatic control system become very large. Consequently we have a problem in how to plan our future expansion of these facilities.

Two courses are possible. One is to put in comparatively small groups of computing equipment like this wherever the pilot simulators or automatic control simulators have to be located throughout the laboratory. Another, and we believe a more economical method of approach, is to put in a central computing system of considerable capacity and connect this central computing system to the various simulators and automatic control equipment, which have to be located in various places around the laboratory, through telephone lines.

A good example of this is experimental work which has been done in a cooperative program with the NASA, the Air Force, and the Navy, using the Navy centrifuge at Johnsville, Pa. One of these programs was in connection with the manned flight problems of the X–15 airplane. In this program the man rode in the cab of this centrifuge so that he experienced the motions that the airplane would experience; and also the accelerations. Since he is going around in a circle in a centrifuge, you see, accelerations many times the acceleration of gravity, can be applied to him.

The pilot's control motions in this case were transmitted to Langley over telephone lines into the computers at Langley. The computers at Langley then sent messages back to Johnsville over telephone lines to control the motion of the centrifuge and of the cab to produce the motions that the pilot would experience in the airplane in an actual flight.

This is one example of this use of telephone lines to cut down on the requirements for computer equipment. What we would like to do in this case is put in a large central computing system at Langley to serve the whole Center. We need this very badly, and we ask your approval of it.

Mr. MILLER. Substantially, the situations at Ames and Langley with respect to computing and analyzing equipment are the same?

Mr. ABBOTT. The situation is very similar, but not quite the same. Langley obtained a building 2 years ago and it is now approaching completion. We can think about doing things like this which we couldn't do before. We will have to think later what else we might want to do at the Ames Laboratory, but our first step is to get the building and get the basic computers in it.

The CHAIRMAN. Why did you delay 2 years in building that at Langley?

Mr. ABBOTT. We did not delay 2 years in building it, sir. We started in immediately when we got the money. The building, if you could see it today, is taking on very substantial proportions. All the steel is long since up. The brick and masonry are rapidly going into place. We have proceeded quite rapidly, sir.

The CHAIRMAN. According to that, then, if you get the money this year for Ames, it will be 2 years at least before you really get underway pretty well with the building?

Mr. ABBOTT. If we get the money in this appropriation on July 1, there is an estimate here of 14 months for the completion. We certainly would be able to make use of this building in that time.

The CHAIRMAN. You will do a more efficient job with this than you have done at Langley, then?

Mr. ABBOTT. I would hesitate to say that, sir.

The CHAIRMAN. That is what you are saying, though. You got the money 2 years ago, you said, and now the building is going up, you say.

Mr. ABBOTT. We were working on the budget for the money 2 years ago. This money became available to us more recently.

Mr. HELDENFELS. It was a supplemental, was it not, that became available in February?

Mr. ABBOTT. I think that is about right and the building is not up, but it is very close to being up at the moment.

Mr. MILLER. If I get it right, it was appropriated for 2 years ago, but the Budget Bureau didn't make the application.

Mr. ABBOTT. No, sir. The Budget Bureau did not hold it up. This was in 1958, I believe—I don't remember at this moment whether it was in a supplemental.

The CHAIRMAN. In any event, you got it and it has been about a year?

Mr. ABBOTT. It has been just about 13 months since we got the money, according to my best recollection. The building is substantially, but not quite completely, built.

NOTE.—The money was appropriated on March 28, 1958.

The CHAIRMAN. Will you do just as well with the Ames building?

Mr. ABBOTT. Yes; we estimate it will be completed in 14 months, and I think we can easily do that because we have some advantage now at Ames. The building is essentially the same size, and some of the same engineering can be used, which should cut down the time.

That completes my presentation, sir. Of course we had a number of other items here. I would be happy to discuss any of them with you.

The CHAIRMAN. I think you have covered it very well. Are there any questions, however, from the members of the committee?

We have three more witnesses and then Dr. Dryden. Mr. Abbott, about how long will the three witnesses require?

Mr. ABBOTT. We have estimated 20 minutes apiece.

The CHAIRMAN. Barring dilatory tactics on the part of the members of the committee, we ought to finish then tomorrow morning.

Mr. ABBOTT. If you wish, we can speed this up.

The CHAIRMAN. I would think so, if we can do it without hurting your case at all.

Mr. ABBOTT. We will do whatever you wish.

The CHAIRMAN. It is 4 o'clock now. The rest of this is in executive session.

Mr. Ducander, will you notify the press that the meeting tomorrow will be in executive session?

Mr. DUCANDER. Yes, sir.

The CHAIRMAN. If there is no objection, then, I think we had better recess until tomorrow morning at 10 o'clock.

(Whereupon, at 4:03 p.m., the committee recessed, to reconvene Thursday morning, 10 o'clock, April 23, 1959.)

1960 NASA AUTHORIZATION

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
Washington, D.C., Wednesday, April 29, 1959.

The committee met, pursuant to notice, at 10:10 a.m., in room B–214, New House Office Building, Hon. Overton Brooks (chairman) presiding.

The CHAIRMAN. The committee will come to order. This morning I see no reason why this should be executive.

Mr. DUCANDER. No, sir.

The CHAIRMAN. We have scheduled this meeting this morning to get a report from the various subcommittees that have worked on H.R. 6512. Mr. Ducander, did you collate the work of the subcommittees?

Mr. DUCANDER. To this extent, Mr. Chairman. The subcommittees all met. They are all ready to report this morning. Mr. Miller called and said he would be just a few moments late and requested that you take his report last. He thought he could be here by that time.

The CHAIRMAN. Mr. Sisk told me last week he would not be able to be here Wednesday.

Mr. DUCANDER. Mr. Hall has his report for him.

The CHAIRMAN. Are you going to report for him?

Mr. HALL. Yes, sir.

The CHAIRMAN. I was going to say we could let that go until tomorrow.

Mr. HALL. No, we are ready.

The CHAIRMAN. Mr. Teague, then you are first up at the bat.

Mr. TEAGUE. All right, Mr. Chairman, we are ready to go.

Mr. Chairman, our subcommittee met. We heard Dr. Dryden, the Deputy Administrator. We heard Mr. Wyatt, who is the assistant to the Director. We heard Mr. Cortright, who is the chief of the advanced technology program. We heard Dr. Homer E. Newell, who is assistant director for space sciences.

We heard Mr. George M. Low, who is chief of the manned space flight program. We heard Mr. Milton B. Ames, Jr., who is the chief of aerodynamics and flight mechanics research division. We heard Mr. Ralph E. Ulmer, their budget officer.

We went through the 11 different items we were responsible for and heard each of these people on each subject. As a result, the subcommittee approved unanimously the request for the figures as submitted by NASA. The subcommittee's part of the budget totaled $165,270,000.

We asked many questions and the NASA officials testified that this budget was in line with the President's budget; that they are hardheaded figures; that there is no fat in them; and that the first request

ran about a hundred million dollars more than this request, but working it down through the Bureau of the Budget they found duplication of their own and so they cut out a number of things.

It is a hardheaded budget, but it may not be enough and they may come back. But they think this is the amount of money they can spend this year to the best adavntage of the program and to the best advantage of the taxpayers.

Mr. Chairman, each member of the committee has a copy of the subcommittee report. If you would like to run through each item, or whatever the desires of the committee might be——

The CHAIRMAN. Do you have a written report?

Mr. TEAGUE. Yes, sir.

The CHAIRMAN. Why not read it to the full committee, then.

Mr. TEAGUE. All right, sir.

Subcommittee No. 2, having considered its assignment relative to H.R. 6512 and having heard detailed testimony on the first half of the research and development budget for the National Aeronautics and Space Administration for fiscal 1960, recommends that the following programs be approved by the full committee:

1. Support of the NASA plant, $16,670,000. This is to provide funds for contractural services, repairs, alterations, minor construction, supplies, materials, and equipment required in the operation of NASA's general activities. This is a $5.2 million increase over 1959, which reflects increased NASA activity as well as the fact that 1959 appropriations were only for a 9-month period, since NASA was not created until October 1958.

2. Support of the Jet Propulsion Laboratory, $8,156,500. This amount is for the operation of JPL by the California Institute of Technology, which laboratory has been placed under NASA for purposes of design, propulsion, operation, and guidance of improved space vehicles. JPL was formerly under the Department of the Army. The amount is the same as authorized in 1959.

3. Research contracts, $5,200,000. This amount is for university and other research fundamental to advancing space technology and is divided between the physical sciences, cosmological sciences, life sciences, engineering sciences, and special research associates. It is a $1.2 million increase over 1959, the greatest part of the increase going to life science studies to ascertain the limitations and hazards of manned space flight.

4. Sounding rockets, $10 million. This amount is for research into the nature, extent, electrification, and dynamical behavior of the earth's atmosphere, for investigation of the electromagnetic and particle radiation of the atmosphere and of certain phenomenon in high atmosphere and surface meteorology. The amount is $5 million more than appropriated in 1959 and will more than double this relatively very cheap method of acquiring basic new information essential to space exploration.

5. Scientific satellites, $22,800,000. This amount is for the construction and instrumentation of satellite vehicles, plus investigation into their improvement. The satellites are for (1) survey observations, (2) quantitative measurements, and (3) complex space laboratories designed to provide much new basic information on magnetic fields and the ionosphere. The amount is about $500,000 less than pro-

vided in 1959, due mainly to advanced technology and existing hardware.

6. Lunar probes, $7,140,000. This amount is to develop vehicles and systems capable of exploring the area of the moon and the moon itself in order to provide information on lunar characteristics and their effects on and behavior in cislunar space. The amount is about $600,000 less than provided in 1959, due in part to operational hardware on hand.

7. Deep-space probes, $6,803,500. This amount is to develop vehicles and systems capable of providing basic information relative to deep-space phenomena, primarily in the regions of Mars and Venus, and to correlate this with new information relative to the processes and characteristics of the solar system—particularly as they influence Earth. The amount here is $10.9 million less than provided in 1959, due to operational hardware and guidance systems on hand and to a different system of budgeting for boosters.

8. Meteorology, $10,800,000. This amount is for the development of a meterological satellite capability to make possible within the next 10 years a fully operational system having worldwide coverage. The plan looks toward fully accurate weather prediction and advanced means of weather control. The amount is $8.3 million more than provided in 1959, the largest part of which will go toward new equipment designed for use in 1961.

9. Communications, $4,700,000. This amount is for the development of communications satellites and techniques suitable for use in a worldwide communications system—including data, voice and television transmissions. The amount is $1.24 million more than provided in 1959, which indicates an accelerated program in communications research and technical services, rather than hardware.

10. Manned space flight, $70,000,000. This is the largest single item in NASA's budget aside from salaries and expenses. It is designed to develop both the hardware and techniques for putting man into space and getting him back safely. The largest parts of this amount are $27,700,000 for the booster rockets needed in the program and $22 million for the development of the actual vehicle, or "capsule," to provide an environment in space in which men can survive. The amount is $12 million more than was programed in 1959, the increase going mainly to capsules, systems design, flight test operations, recovery research, and wind tunnel models.

11. Space rendezvous techniques, $3 million. This amount is to determine the requirements and system components necessary in order to regain contact with satellites and space vehicles once they have been launched and are in space. This is a new item and had no parallel in the 1959 budget.

The above budget items total $165,270,000. NASA officials have testified that they are in line with the President's budget and are hardheaded figures with no fat in them. It was further emphasized that these sums represent all the money which NASA can foresee at the present time as necessary. Officials testified they would return to ask for more funds if future events warranted.

All figures are those specifically requested by NASA. They have been approved unanimously by the subcommittee without change.

The CHAIRMAN. As I understand it, your subcommittee is satisfied with the figures that NASA gave to the full committee.

Mr. TEAGUE. Correct.

The CHAIRMAN. Therefore you recommend the approval of your portion of the figures in the bill presented to the full committee.

Mr. TEAGUE. We do, Mr. Chairman.

The CHAIRMAN. Do you have any comment as to any particular item or was there any controversy over any?

Mr. TEAGUE. No, sir. Our biggest item was, of course, the man-in-space program, which is centered down at Langley Field, which is $70 million. Of course it is an unknown quantity, and obviously the people concerned can't know the exact amount of the budget.

There is no history of it. The subcommittee discussed, after these gentlemen left, the attitude of the people who appeared. Our opinion was that it was a very dedicated group of men who had done the best job possible.

The CHAIRMAN. So you recommend the approval?

Mr. TEAGUE. I recommend the approval, Mr. Chairman.

Mr. MCDONOUGH. Mr. Teague, is the man-in-space flight item that you refer to, $70 million, part of the development of the Mercury project?

Mr. TEAGUE. Yes, it is.

Mr. MCDONOUGH. We have obligated ourselves to the extent of $20,750,000 on it up to now?

The CHAIRMAN. That was in the supplemental.

Mr. TEAGUE. There is $27,700,000 which is for booster rockets and then there is $22 million for the development of the actual capsule.

Mr. MCDONOUGH. That is all the questions I have.

The CHAIRMAN. Mr. Fulton.

Mr. FULTON. I think it would be helpful to have in the record the amount of the original request, which NASA voluntarily reduced through the elimination of overlapping, and then the amount the budget cut it so we can see it.

Mr. TEAGUE. This is a very short report for the benefit of the committee. We said to these gentlemen, "We believe we could help you more if you would give us a carefully detailed report to go in the full committee report."

Those figures will be in there. There will be about 300 words on each one of these items to go in the full committee report. But the report today is rather short for the benefit of our committee.

Mr. FULTON. So we will have the history of the figures?

Mr. TEAGUE. Correct.

(The material referred to follows:)

OPERATIONAL SUPPORT OF NASA PLANT

The research and development appropriation title includes funds required on a no-year basis to provide contractual services, repairs and alterations, minor construction, and supplies and equipment for all NASA operated facilities. A separate salaries and expenses appropriation title contains all items requiring obligation on an annual or fiscal year basis; these include salaries, life insurance and retirement contributions, travel and transportation, rents, and all utilities including the large item of electric power for NASA wind tunnel operations.

The recommended amount for operation of the NASA plant in 1960 is $16,670,000. This compares with $11,726,102 for the equivalent items during fiscal

year 1959 or an increase of $4,843,898. The increase reflects the expanding requirements for new space research and also the urgent need to overcome some of the accumulating deficiencies in the amount of material and facilities support for NASA's extensive in-house research and development effort. This research work is carried on principally at NASA laboratories in Langley (Virginia), Lewis (Cleveland, Ohio), Ames (Palo Alto, Calif.), Edwards (California), Wallops Island (Virginia), and the Beltsville Space Fight Center groups now occupying temporary quarters at NRL in Washington, at Langley, and at Lewis. Like other modern research, the effective conduct of both aeronautical and space research now requires increasingly specialized facilities, more complicated equipment and instrumentation, and more extensive shop services. However, in recent years, the NASA laboratories, through lack of funds, have had to curtail the modernization and equipping of their facilities. One good criterion is the ratio of support funds available for contractual services, supplies, and equipment in relation to the funds spent for personal services. In 1950, these laboratories, then under NACA, had support funds equal to 40 percent of the personal services item; since 1953, this has been reduced to an average of 23 percent, except for the fiscal year 1958 when 25 percent was available. The current budget request proposes to improve this ratio slightly, bringing the ratio to 26½ percent.

There are four main areas of increase:

(*a*) Contractural services from non-Government sources involves $935,000, an increase of $336,000 over 1959. Practically all this increase is for additional machine shop and metal fabrication work of a specialized kind which is uneconomical to provide on a full-time basis using Government shop facilities.

(*b*) Facility repairs and alterations (for projects costing less than $200,000) require some $562,000 additional, or a total of $1,728,000. Rapid changes in research requirements dictate that continuous attention be given to adapting existing facilities for new studies. This item proposes to make a substantial reduction in the backlog of necessary improvements. Major new facilities or capital projects costing more than $250,000 are requested separately under the construction and equipment appropriation title.

(*c*) The supplies and materials request for $8,283,000 is an increase of $2,075,000 over 1959. Three-fourths in this ($1,612,000) is primarily attributable to the greatly increased number of rocket launchings in 1960. In this area, an additional $1,049,000 will be needed for liquid rocket propellants, $358,000 more for rocket engines and models, and $205,000 more for electronic instrumentation.

(*d*) Lastly, the equipment requirements are $5,610,000 or some $2,251,000 over last year's purchases. NASA has furnished the committee with detailed analyses of these equipment needs by category and location in which the items will be used (see pp. 220–225 of NASA estimate). Of the $2,251,000 increase recommended for both replacement and new equipment, 70 percent (or $1,602,000) is for the purchase of new types of scientific and research apparatus. All new equipment needs, totalling $2,776,700, have been detailed by individual item required, and by location. Under plans presented to the committee, $105,000 would be required for new Langley equipment; $899,000 for Ames; $1,443,700 at Lewis which is undergoing major changes to equipment for rocket propulsion research; and $339,000 at the Edwards high speed station.

SUPPORT OF JET PROPULSION LABORATORY PLANT

The Jet Propulsion Laboratory is a Government-owned research and development laboratory, located at Pasadena, Calif., operated by the California Institute of Technology. Jet Propulsion Laboratory has been a pioneer and leader in many aspects of ballistic missile and space flight.

Research and development functions of Jet Propulsion Laboratory were transferred to the NASA by a Presidential order dated December 3, 1958, except for such functions as relate primarily to military operations and weapons systems development programs. Under the previous contract with the Department of the Army, a certain fraction of Jet Propulsion Laboratory total effort was underwritten for supporting research and development in the general field of technology for which Jet Propulsion Laboratory has competence. The Department of the Army funded this research and development on a calendar year basis.

For the calendar year 1959, this supporting research funding was estimated at $8,156,500; half of this sum was transferred to the NASA from the Department of Defense to cover the first half of calendar year 1959.

The NASA plans to continue the supporting research at Jet Propulsion Laboratory in the general fields of guidance and control, propellants and propulsion systems, materials, instrument development, and related areas. This supporting research and development will be carried on in calendar year 1960 at the same total level as that during calendar year 1959. The NASA is therefore requesting a sum of $8,156,500 to fund this portion of the Jet Propulsion Laboratory effort from the fiscal year 1960 budget.

RESEARCH GRANTS AND CONTRACTS

The objectives of the NASA program of research grants and contracts are first, to augment NASA research capabilities by utilizing the scientific potentials of universities and other organizations and, second, to encourage additional scientists to work in fields fundamental to aeronautical and space technology, thereby broadening our foundation in these fields. The scientific and technological areas being supported encompass physics, chemistry, mathematics, planetary sciences, astronomy, astrophysics, fluid mechanics, propulsion and power, navigation and guidance, communication, materials, structures, and the so-called life sciences which include biological physics, biochemistry, physiology, any psychology.

The NASA program supported by grants and research contracts is a basic research program, the objective of which is to secure new fundamental knowledge. From research in physics we will expect to learn more about the fundamental nature of matter and energy. This is a prerequisite for major breakthroughs in space technology. Of particular importance are areas dealing with the physics of hot ionized gases or plasmas, cosmic rays, and high energy particle physics, physics of solids, and physics of high temperature matter. From research in chemistry we will expect major contributions toward materials of construction and means of propulsion of future space vehicles. Some of the problems include the nature of energetic and fast chemical reactions, photochemical processes (relevant to use of solar energy), and chemical processes in materials in the solid state.

Research in astronomy and the planetary sciences comprises a variety of studies dealing with calculation and acquisition of accurate orbit and position data for planets, surface features of planets and the moon, atmospheres of the earth and planets, geophysics, and other topics. Astrophysics deals with the nature and distribution of matter and energy in space, the processes occurring in the stars, the formation and evolution of galaxies and the cosmos. Major questions such as the possible utilization of the matter and energy in space and the hazards to space flight of particles and radiation can only be answered by further basic understanding through astrophysical and other research.

Research in the engineering sciences of fluid mechanics, propulsion and power, etc., is necessary for major advances in the technology of space flight. The areas include research in hypervelocity fluid dynamics for application to high-speed entry into the atmospheres of the earth and other planets, the production of energy and conversion of energy among various forms for use in propulsion and auxiliary powerplants, space flight navigation and flight path control, long-distance communication, and materials and structures for space vehicles.

Finally, to insure that man may travel in reasonable safety and function efficiently under the extreme conditions associated with space flight, basic research in the life sciences is required. These sciences include biological physics and chemistry which are concerned with the response of living organisms to radiation, weightlessness, and perhaps other physical conditions not now known and with maintaining proper chemical environment necessary to support life. Research in physiology and psychology are required to study man's functioning and behavior under the new and arduous conditions.

Currently, contracts and grants have been placed with the following institutions: Yale University, Connecticut; University of Maryland; National Academy of Sciences; the Rice Institute, Texas; Rensselaer, Polytechnic Institute, New York; University of Michigan; University of California. An even wider range of institutions will be incorporated in the program as it develops.

SOUNDING ROCKETS

The principal aim of the sounding rocket program is to explore the earth's upper atmosphere and to investigate its relations to the sun.

The earth's upper atmosphere has a "weather" of its own, controlled largely by energy from the sun brought in by solar X-rays and ultraviolet light. The upper atmosphere "weather" is just as dynamic as the weather of the lower atmosphere, involving large scale circulations, winds, and seasonal changes. In the upper atmosphere, however, electricity and chemical changes play the predominant role, whereas in the lower atmosphere water vapor plays the major role.

The high atmosphere cannot be adequately observed and investigated from the ground or in balloons. Hence the sounding rocket is used. The $10 million in funds requested for fiscal year 1960 include moneys to purchase about 100 sounding rockets plus their research payloads. Since both the rockets and their payloads are long lead time items, it should be noted that many of the 100 rockets to be fired during fiscal year 1960 were bought in fiscal year 1959, while many of those bought from fiscal year 1960 funds will be used for firing in following years.

The fiscal year 1960 request also includes moneys to develop a very high altitude sounding rocket capable of carrying scientific payloads to several thousands of miles altitude. One aim of this development is to produce a sounding rocket that will be much cheaper than the Scout satellite vehicle, which, while inexpensive as a satellite launching vehicle, would be too clostly to use for atmospheric soundings.

The fiscal year 1960 request also includes moneys required for the design of sounding rocket experiments, the design and development of special measuring instruments, the preparation of mobile rocket launching units and radio ground stations, the launching and reception of data from about 100 sounding rockets, and the reduction and analysis of the data.

Whereas the sounding rocket program is fundamental research, and has as its primary aim the extension of the frontiers of knowledge, nevertheless the results will be of practical value. The meteorological and communications fields, for example, may both be expected to benefit. In this last connection, previous rocket investigations of the earth's ionosphere have already led to an improvement by a favor of three in forecasts of what shortwave frequencies will be usable for radio communications.

SCIENTIFIC SATELLITES

Scientific satellites are to be launched into orbits which lie between 150 and 100,000 miles above the earth's surface. They have two major purposes: (a) to measure the characteristics of the outer reaches of the earth's atmosphere; and (b) to measure the particles and radiations which originate in outer space and which cannot penetrate to the earth's surface through the atmosphere. A single satellite is able to make such measurements over many months, years, or even decades; and with the proper choice of an orbit over the north and south poles it can sample the whole outer atmosphere as the earth rotates below. Such satellites have already carried scientific instruments weighing as little as 21.5 pounds, and will carry weights of several tons in the future.

Satellites yet to be launched in 1959 will carry lightweight exploratory payloads to survey quantities such as the earth's magnetic field and radiation from the sun, in regions of space never examined before. During 1960 these payloads will become more sophisticated, as data from earlier satellites provides a better picture of the conditions to be encountered. Meanwhile, exploratory biological experiments and heavier payloads such as astronomical telescopes which can be pointed from the ground, will be developed and launched when ready.

A number of important discoveries have already been made by the first few scientific satellites. The air above 200 miles is now known to be many times thicker than had been believed; consequently more thrust will be required to maneuver spacecraft in this region. Van Allen discovered the great radiation belt using the first American satellite. The hazards to both instruments and man must be completely understood before this belt can be penetrated with safety. These results, important though they may be, are minor compared to the flood of new knowledge which will come from scientific satellites over the next decade.

The $22,800,000 in fiscal year 1960 funds are intended for laboratory research;

payload design, development, and test; and reduction and analysis of the resultant scientific data. The funds will provide for the purchase of two additional Juno boosters and of payload systems for Juno II and Delta vehicles.

LUNAR PROBES

Lunar probes are instrumented rocket vehicles which measure and investigate physical phenomena in the space between the earth and the moon. Advanced vehicle systems can also investigate space in the close vicinity of the moon, the lunar surface with its mountains and valleys, and the moon's interior. Studies with lunar probes will provide the basic scientific data and lay the foundation for lunar explorations which will eventually include the exploration of the moon by man himself.

These lunar probes are scheduled to be launched during the next year. Equipment and instrumentation are designed to provide preliminary information on some of the physical characteristics of the moon itself as well as the space to be crossed. Apart from data to be radioed back to earth by all lunar probes during flight, two of the probes are expected to impact on the moon. While the instrumentation will be completely destroyed, information will be obtained during the last few seconds prior to the impact about the presence or absence of a lunar atmosphere, the nature of the moon's surface, and any evidences of radioactive materials on the moon.

The third probe will be a lunar orbiter, designed to become a satellite of the moon itself and to transmit back while orbiting a few hundred miles above the moon's surface.

The funds totaling $7,140,000 requested for fiscal year 1960 need to be committed during this fiscal year to continue development of scientific instruments and technical equipment for the complex requirements of more advanced methods of exploration. The next step, planned for 1961, has as its objective the landing of instruments designed to withstand the final descent, slowed down by retrorockets. This will constitute the first establishment of a fixed, if small, extraterrestrial observatory which can transmit data between the earth and a celestial body.

A successful landing will signal the start for the factual exploration of the moon. As with the earlier lunar probes, Pioneers I, III, and IV, the scientific data obtained will provide the information for the next objective: the design and specifications for the characteristics of vehicles which can safely transport man across some 200,000 miles of space and land on our natural satellite.

While the lunar probes to be launched will give us a better understanding of many of the basic physical and biological phenomena predominant in our solar system, not all of the questions puzzling to us can be answered by even the most sophisticated instrumentation conceivable. They will have to wait until man himself has reached the moon and can conduct detailed surveys on the spot.

DEEP SPACE PROBES

The principal aim of the deep space probe program is to determine what exists and what is happening in outer space beyond the earth's atmosphere.

In outer space lie the planets, the sun, and the stars. Through it move meteors, asteroids, comets, various radiations from the sun and stars, clouds of electrons and other charged particles, magnetic fields, and perhaps many other unknown quantities. Observations and measurements on these quantities from the surface of the earth are limited by the obscuring and distorting effects of the earth's atmosphere, and the great distances between the observer and the object of study. With deep space probes, it becomes possible to measure these quantities with instruments sent to the very region of study.

From a practical point of view it is essential to make such measurements and observations before undertaking manned flight into interplanetary space.

Some of the $6,803,500 in funds requested during fiscal year 1960 will be devoted to the scientific and technical studies of the guidance, control, tracking, and radio systems required for deep space probe missions. Funds are also required for the design of measuring instruments needed to investigate the properties of interplanetary space and the planets. Funds are included for the assembly and launch of experimental vehicles, for the reception of radio data from the probes, and for the reduction and analysis of the information obtained.

Two space problems are scheduled for firing either late in fiscal year 1959 or early in fiscal year 1960. Two others will be under preparation during fiscal year 1960 for launching during the following year.

METEOROLOGY

What is being done

Two meteorological or weather satellite experiments were carried over from the IGY program. One was designed to take pictures of the cloud distribution over large areas of the earth. Another was designed to measure the unequal heating of the atmosphere by the sun. The first experiment has already been launched by a Vanguard rocket, while the second will have two launch attempts by midsummer.

An effort is underway to prepare a more advanced weather satellite. This satellite project, called Tiros, originated with ARPA and has been recently transferred to NASA. The satellite itself will make use of television cameras and a variety of radiation detectors to observe clouds and detect storms, and to measure in detail the heating of the atmosphere. One such satellite is scheduled for launch by the end of this year and a second in the spring of next year.

The next step beyond Project Tiros will be to develop a prototype of an operational weather satellite designed for a 700-mile-altitude polar orbit. This satellite will have attitude control so that its instruments always point toward the earth. It will again have television or equivalent picture-taking equipment for daylight observation of clouds. In addition, its advanced infrared radiation detectors will permit cloud observation at night as well as measurement of properties of the atmosphere. Development of this satellite is a major undertaking and will consume over two-thirds of the fiscal year 1960 meteorological satellite funds. Two launches with a Vega booster are scheduled for 1961.

For the more distant future, research and development on satellite-borne radar will be initiated. Research and development on 24-hour meteorological satellites to remain "stationary overhead" at 22,300 miles above the equator will also be started. An ultimate operating system will probably use up to six satellites of the 700-mile-high polar orbit variety and four of the 22,300-mile satellites. It will probably take a decade to achieve this goal.

Where it is being done

The efforts of many Government, industrial, and university organizations throughout the country are being applied to the meteorological satellite program. On Project TIROS, for example, the following groups are involved:

1. U.S. Army Signal Research and Development Laboratory, Fort Monmouth, N.J.
2. U.S. Air Force Ballistic Missile Division, California.
3. U.S. Weather Bureau, Maryland.
4. U.S. Air Force Cambridge Research Center, Massachusetts.
5. Navy Photographic Interpretation Center, Maryland.
6. Atlantic Missile Range, Florida.
7. Douglas Aircraft Corp., California and Oklahoma.
8. Space Technology Laboratories, California.
9. University of Wisconsin.
10. Advanced Research Projects Agency.
11. National Aeronautics and Space Administration.

What these developments might mean to us

The benefits to be derived from improved capacity in meteorology include convenience in planning personal activities, protection of life and property from weather disasters; safeguarding transportation; crop planning, control and protection; industrial planning of weather-dependent products, outdoor enterprises, and heating and cooling loads; eventual limited weather control; and goodwill in return for providing these services to less fortunate people. In addition, the same meteorological data required for worldwide civilian needs can, by proper handling, be made to meet special military needs as well.

Just how much improvement in the science and practice of meteorology will result from the satellite use is not certain. We are confident of its storm and cloud detecting ability and have great hopes that its other measurements will make possible significant improvements in long-range forecasting.

COMMUNICATIONS

What is being done

The NASA has undertaken a program to develop the capability of using satellites for long-range communication. Of the several possible approaches to the problem, NASA has chosen to concentrate on what is known as a passive reflector satellite. With this type of satellite, a strong radio signal is beamed at the satellite and its weak reflections are picked up by powerful receiving stations which may be thousands of miles distant.

The first such satellite will be a 100-foot diameter inflatable sphere which will be placed into a 1,000 mile high orbit by the end of 1959. Experiments in bouncing radio signals from the satellite will be conducted between the east and west coasts of the United States. During 1960 and 1961 three additional launches of passive reflector satellites will be made, one of which is planned to carry a number of such satellites to an altitude of 2,500 miles.

In an ultimate operating system using this type of communication satellite, it is envisioned that as many as 25 satellites at this altitude will be required to insure virtually uninterrupted communications. This is not an unreasonable requirement, since as many as 10 can be launched with a single Vega booster.

The passive satellites will be available for all to use. Because they carry no equipment to restrict the number of channels, many users can make simultaneous use of them, subject only to the well-known problem of frequency allocation.

Another attractive type of communication satellite is the active repeater. This satellite receives signals from the ground and rebroadcasts them to a station over the horizon. It must carry a receiver, transmitter, and antenna and must ultimately be altitude-controlled for antenna pointing. The satellite will require internal power. The most likely ultimate system would make use of three such satellites equally spaced in the 22,300-mile equatorial orbit.

The active repeater program is being primarily carried by the Department of Defense. The NASA is programing some funds to develop special electronics equipment tailored to civilian requirements for this type of satellite, one of which is the relay of meteorological data.

Where it is being done

The first NASA experiments in the passive reflector field will involve the following organizations:

1. Jet Propulsion Laboratory, California.
2. Naval Research Laboratory, Maryland.
3. NASA Langley Research Center, Virginia.
4. U.S. Army Research and Development Laboratory, New Jersey.

In addition, all interested parties have been invited to prepare to make experiments in reflecting signals from the satellite and will be aided in every way possible by the NASA. Orbit information supplied by the NASA will help such participants lock on to the faint signals.

A number of major communications companies have expressed great interest in the data and at least one is making major investments in equipment to participate in the experiment.

What these developments might mean to us

By 1962 the present transatlantic telephone cable will be saturated with messages. By 1970 there is predicted a sevenfold increase in message units to a total of 21 million. At the present minimum toll of $12 from New York to London, there is a potential gross income of over $200 million per year. However, best estimates of the investment required to operate a satellite system lead one to predict greatly reduced rates for transatlantic telephone calls.

Telephone communications to more remote parts of the world are even less satisfactory. We have no transoceanic television at all. There is every reason to believe that communications satellites will eventually prove to be a solution to all of these deficiencies.

MANNED SPACE FLIGHT

The manned satellite program is but one in a series of systematic steps leading toward interplanetary flight. But, for many reasons, it is a most important step. The type of vehicle needed for successful reentry into the earth's atmosphere from a satellite orbit will, in the future, be used to return man from satellite stations or from more distant places. But even more important, it is the first vehicle

that can put man into a zero gravity environment for a prolonged period of time; thus it will permit a detailed study of the many physiological problems associated with weightlessness.

The problems associated with flight of a manned satellite may be briefly stated as follows. It is first necessary to provide booster rockets with sufficient impulse to place into orbit a satellite weighing in excess of 2,000 pounds. These booster rockets must be highly reliable, and safety procedures must be developed to cope with as many eventualities as possible. Guidance systems must be capable of establishing sufficiently accurate orbits to permit completion of the mission. Once in orbit, the satellite must be habitable for the duration of the flight, and must be instrumented to record useful data. The orbit must be precisely determined from the ground prior to the application of retrothrust for reentry into the earth's atmosphere.

Reentry is one of the most hazardous aspects of manned space flight. During this phase of flight the vehicle and its occupant are threatened by large deceleration loads and high temperatures. Surviving these, the vehicle must land safely at some preselected point.

Project Mercury, the first manned satellite project, which is now well underway, has the objectives of achieving orbital flight and successful recovery of a manned satellite at the earliest practicable date, and to investigate the capabilities of man in a space environment. In order to accomplish these objectives with a reasonable assurance of success, a reentry vehicle of the ballistic (nonlifting) type was selected for this project. This vehicle not only represents the simplest and most reliable configuration, but has the additional advantage of being sufficiently light that it can be fitted on an unmodified IDBM booster.

The Project Mercury satellite, therefore, will consist of a capsule which is launched into orbit by the Atlas booster. Within this capsule, the man is supported in a form-fitting couch, so that he can withstand the high acceleration loads during launch and reentry. The capsule also contains a life support system and sufficient food and water for a 1-day period in space. During this period, the pilot's reaction to space flight will be measured, and data will be transmitted to the ground.

Descent from orbit will be initiated by firing small rockets in a direction opposite to the flight path. After the satellite enters the atmosphere, it will be slowed down by aerodynamic drag. The frictional heat, accompanying this drag, will be dissipated in a heat shield. Once the capsule has slowed to less than the speed of sound, a parachute will be deployed; a water landing is planned, although recovery on land or water will be feasible.

The ballistic orbiting vehicle will answer many questions concerning the effects of weightlessness on man's capabilities and behavior in a space environment. Such questions must be answered before longer space flights can be realized, and before more complicated tasks can be assigned to the pilot or occupant.

However, the ballistic capsule is not the only vehicle suited for manned space flight. Because this vehicle cannot maneuver during reentry, recovery at a small preselected site is improbable. This fact places an added burden on the recovery system. In addition, the decelerations encountered during a ballistic reentry, although well within the limits of human tolerance, are quite large. Both of these drawbacks of the ballistic vehicles can be circumvented by following a reentry trajectory wherein some aerodynamic lift is provided. Because a lifting vehicle can be controlled, recovery at a definite site is feasible. The maximum decleration encountered during a lifting reentry can be less than 2 g., as compared with 8 g. for the ballistic reentry.

It is clear, therefore, that a lifting reentry vehicle will be of considerable importance in the study of man's capabilities in a space environment; and it may be of even greater importance as a "shuttle" vehicle between earth and an orbiting space science laboratory, or as a vehicle to be used in the return from moon or interplanetary explorations.

Project Mercury is the NASA's most urgent program, and is being pursued at a rate that will give this nation a highly reliable space vehicle at the earliest practicable date. In order to continue our efforts at the present accelerated rate, we are requesting $70 million for manned space flight in fiscal year 1960. Approximately 70 percent of these funds are required to complete the funding of 12 satellite capsules and of the Little Joe, Redstone, Jupiter, and Atlas boosters. Most of the remaining funds are needed for flight, range, and recovery opera-

tions, for flight test models, and other related equipment. Only a small percentage of the requested funds has been reserved for studies of advanced manned satellite vehicles.

Contracts in support of the Mercury program have been placed with:

1. North American Aviation, California.
2. Minneapolis-Honeywell Regulator Co., Minnesota.
3. Electro Mechanical Research, Inc., Florida.
4. Cook Electric Co., Illinois.
5. Ballistic Missile Division (Air Force).
6. Army Ballistic Missile Agency (Chief of Ordnance, Army).
7. Aerolab Development Co., California.
8. Thiokol Chemical Corp., New Jersey.
9. Army Ordnance Missile Command.
10. McDonnell Aircraft Corp., Missouri.
11. Radioplane, a division of Northrop Corp., California.

SPACE RENDEZVOUS TECHNIQUES

As the art of space flight advances, particularly in the areas involving manned flight, it will be desirable to be able to execute rendezvous contacts between vehicles. In particular, it is visualized that permanent orbiting manned laboratories will be essential as a forerunner to manned space flight to other planets. These vehicles have not yet been designed, but it is expected that they would include technological laboratory features for the investigation of the reliability of components and equipment intended for long duration space flights. Such permanent laboratories will have to be resupplied and remanned from time to time, and hence systems must be devised that will permit accurate and certain contact between the permanent laboratory and the rendezvousing supply craft.

It is already known that a number of major technological problems must be solved before assured rendezvous flights can be accomplished. Among these problems are the establishment of referencing methods for fixing the relative positions of both vehicles; the development of accurate, light-weight target acquisition equipment that can be used for locating the space station or laboratory from the supply craft; the development of very accurate guidance and control systems to permit the establishment of very precise flight paths; and the development of sources of control power. It is anticipated that other equally complex problems will be uncovered as soon as active research and development of rendezvousing vehicles is entered into.

A sum of $3 million is being requested in fiscal year 1960 to initiate studies on various aspects of the rendezvous problem and to begin early research and development of components that appear promising as a solution to the problems. This money will be expended through contracts with industrial firms and other government agencies having competence in the field.

The CHAIRMAN. That is a very fine report Mr. Teague has presented. All your members officiated properly?

Mr. TEAGUE. Yes, sir.

The CHAIRMAN. You are satisfied with the report of the subcommittee?

Mr. TEAGUE. We had, to a considerable extent, an unofficial meeting, all sitting around a table. We went through it item by item.

Mr. FULTON. The question comes up, because we are all interested in a good, efficient, and a going space program, about the things that were cut. Do you as a subcommittee feel that any of them should be included, or do you agree with the presentation?

Mr. TEAGUE. We agree with the presentation. Some of those cuts were complete duplication of other programs that were found when they started conferring with the Bureau of the Budget. They found—I have forgotten whether it was Air Force, Navy, or what—another agency of the Government was doing exactly the same thing. That was a $60 million item eliminated.

Mr. FULTON. But there is no substantial program that is necessary for the security of the United States that has been cut out?

Mr. TEAGUE. Not according to the men who testified.

Mr. FULTON. Thank you.

The CHAIRMAN. You have heard the report.

Mr. HECHLER. Mr. Chairman, may I ask a question of Mr. Teague? You mentioned that the man-in-space program was the most expensive of these, and that there was some uncertainty about the precise amount of expenditure needed.

I was wondering whether it would hamper or impair this program to appropriate or authorize the appropriation of a lesser amount of money and allow them to come back for additional amounts, if needed? I wondered if this general theory was considered.

Mr. TEAGUE. Yes; it was considered. I think in the bill there is a provision where items can be raised 5 percent but you would not increase the total appropriation. After going through this very carefully with these men, we thought the proper thing to do was to back their figures.

The CHAIRMAN. Are you ready for the question?

All in favor of approving the report of the subcommittee, make it known by saying "Aye."

(Chorus of "Ayes.")

The CHAIRMAN. Opposed?

(There were none.)

The CHAIRMAN. The subcommittee report is unanimously approved. We thank the subcommittee.

The next subcommittee to report is Mr. Anfuso's subcommittee.

Mr. ANFUSO. Mr. Chairman, our committee had several meetings and I might say that we had the full cooperation of all the members, both those on the Republican side and the Democratic side; and we were unanimous in our decision.

Subcommittee No. 3 met at 3 p.m. on Friday, April 24, 1959, in the Armed Services Subcommittee Hearing Room No. 304 of the Old House Office Building, and we had before us Dr. Hugh Dryden, Deputy Administrator of NASA; Albert F. Siepert, Director of the Office of Business Administration; and Ralph E. Ulmer, Acting Deputy, Budget and Fiscal Division; and Mr. Vaccarro, Business Manager of the Space Projects Center in Beltsville.

As you know, we were assigned the salaries and expense portion of the budget. It should be noted at the outset two things pertaining to this requested authorization. The first is that this is the first requested authorization on the part of the agency for a full fiscal year, since heretofore funds were received from allocations made to the National Advisory Committee for Aeronautics, and also from the transfer of funds from the Department of Defense. I suppose, Mr. Chairman, this applies to all subcommittees.

Secondly, although our space efforts have been accelerated, there have been no appreciable increases for purely administrative purposes or for the various research centers. I should like to emphasize to the credit of the agency that there have been no individual salary increases requested. There is anticipated a requirement of 1,027 additional employees during the 1960 fiscal year, which would add 150 employees to the NASA headquarters here in Washington and 720 to the Space Projects Center at Beltsville, Md.; 153 to the Pilotless Aircraft Station at Wallops Island, Va.

You will note that most of these personnel are called for at the Space Project Center—the figure I mentioned before, 720. This installation, which had 527 employees in 1959, has as its function, as you know, the planning, research, coordination, and conduct of space flight programs and the analysis of data obtained.

In other words, it is upon this particular project that all the other projects evolve. The NASA budget calls for a total estimate of $485 million. Of this amount $94,430,000 is allocated to salaries and expenses. This is slightly under 20 percent of the total requested authorization, Mr. Chairman.

Eleven million dollars is for additional personal services, and $9 million is accounted for in travel, communication, leases, and so forth—brought about by the increased activities of the agency.

These requirements result from the provisions of the act itself. For example, the act provides for an Inventions and Contributions Board for the handling of certain patent matters. This department, together with the increased staff of the public relations office, accounts for the additional personnel

The installation at Wallops Island, which has been a small rocket launching range and so operated for approximately 14 years, has heretofore used some firing personnel from the Langley Research Center. The additional facilities that will be established at Wallops Island and the requirement of permanent personnel will enable Wallops Island to become a self-contained unit and will enable it to function as a separate NASA installation.

Previously, as you know, Wallops Island had been a field station of Langley. I do call your attention to the two major items where are found the greatest increase over the 1959 fiscal appropriations, namely, "Travel and communications." The travel request is a requirement of approximately $3 million, and the communication request is approximately $3.75 million. These two items are closely connected in that the expanded program of worldwide travel and observation and installation, and the proper transmitting of received data necessitates both of these requests.

These installations are necessarily worldwide in scope, established in Peru, for example, Argentina, Spain, India, Japan, Hawaii, and south Africa, as well as many varied locations in the United States.

Of the communication request, $3 million is because of specialized communication services—namely, the leasing of direct communication lines from various tracking and launching installations to computer centers; the leased lines for the minitrack global range system, which is in excess of $1 million; and the leased lines from Wallops Island to NASA headquarters, Langley and Beltsville. The New York computer station and the Atlantic Missile Range are an item of approximately $500,000.

The increased facility at Wallops Island, which will enable the launching of larger rockets, calls for a more highly perfected communication network for down-range intercommunication system, operation and firing control, and countdown intercom system calling for an expenditure of $370 million.

The matter of travel estimates is based on the 1958 experience of NASA, which had an average of something less than $100 per em-

ployee, and the Vanguard travel experience, which showed an average of approximately $2,800 per employee. The requested budgetary item for travel has been reduced from other estimates to a calculated figure of $330 per employee for the 1960 fiscal year.

Since we are in an experimental stage, we must realize that in the course of time this estimate can go up or down. Since this agency does not have any experience upon which to base a travel request, considerable leeway should be allowed to determine the pattern of expenditure for the future. If the estimated figure is insufficient, a supplemental appropriation can be requested.

Therefore, we thought that the $330 for the time being was an all right figure, and we went along with it.

There appears a third item of some magnitude for the leasing of certain analog and digital computers. This equipment can be maintained and operated under lease at a greater savings than operation under direct purchase, so we favor the direct leasing.

The remaining miscellaneous items under the S. & E. Division of the appropriation request are primarily contributions to employee retirement plan; life insurance program; and certain uniform allowances—all as established by statutory requirements—and account for the $4.5 million.

The greatly expanded scope and the greater agency of the NASA program make it difficult to estimate NASA expenditures for the coming year. The subcommittee believes that this authorization is a reasonable request which will allow NASA to determine its own spending experience commensurate with the urgency with which the Congress has indicated it should act.

Much of the testimony has been classified and it clearly supports the need for the requested authorization.

I might add, Mr. Chairman, that this entire report was gone over very carefully last evening by the full subcommittee. Every member of the subcommittee was present. Mr. Fulton and Mr. Van Pelt and all of the other members on the Democratic side made very valuable contributions, and the staff prepared it last evening and completed it this morning.

I think I should like to read just one statement into the record which is the result of a very excellent question asked by Mr. King of the subcommittee, which I think is a good explanation for any question that may be asked on the floor as to any of the subcommittees' work—not only our own but the other subcommittees. I think it shows the concern of this particular committee—the entire committee.

It shows how earnest every member is to try to do a good job. Mr. King, for example, asked:

> But would you care to state something into the record covering the general point to indicate that you are satisfied that these figures represent the absolutely irreducible minimum under which you could not operate efficiently and do the job that has been assigned to you?
>
> Dr. DRYDEN. Perhaps two statements will help. First of all, we consider that a policy has been established by Congress and by the administration that they want to make this country a leader in space technology and space exploration. To do that we have estimated the rate at which we think we can go to do this. You have heard the testimony that it will take about 18 months to accomplish the same weight capability in space that our competition already has demonstrated.

We feel that this is a minimum budget to fulfill that kind of a responsibility. If Congress wants to establish a different policy, why, that is a different matter. But if we are to meet the responsibilities that are put upon us by the act and by the statements of policy, both of Congress and of the administration, we do not see how we can do it with less.

We have not put into this budget any contingencies. We have said throughout our discussions, both within the administration and in the Congress, that we are in a new field and a rapidly changing field. We do not have a basis always of determining to the last penny what things are going to cost.

This money is being provided on a new-year basis. We are going to spend it just as efficiently and just as effectively as we can. If we have some of it left over to go into the following year, then we don't have to ask as much in the following year.

On the other hand, we have said that if we find that conditions beyond our control, either technical or optical that we run into, or similar things demonstrated the needs for more funds, we will be back through channels to the Congress with a request for what we think we need to meet this responsibility.

I think that that is a very fair statement, Mr. Chairman. It analyzes the thinking of the entire NASA organization, and I think it is on the right track and we are unanimous in supporting their full request insofar as salaries and expenses are concerned.

The CHAIRMAN. So you move the approval of the subcommittee report by the subcommittee?

Mr. ANFUSO. I do.

Mr. FULTON. I second that.

The CHAIRMAN. It sounds like a very fine report, then. We appreciate your interest and that of your subcommittee in working diligently on this matter of salaries and expenses, which is a very important matter.

You have all heard the report of the subcommittee. All in favor of approving it say "Aye."

(Chorus of "Ayes.")

The CHAIRMAN. Opposed?

(There were none.)

The CHAIRMAN. The "Ayes" have it. It is unanimously approved.

We will have the report of your subcommittee then, Mr. Hall, if you wish to give it for Mr. Sisk.

I want to say this before you begin, that Mr. Sisk has shown a very active interest in this matter and he has worked diligently. He has convinced me that he is very interested in it and in a sense I feel a little badly about taking the matter up in his absence. Were it not in your competent hands, Mr. Hall, it might be different.

Mr. HALL. Mr. Chairman, as stated by you, Mr. Sisk could not be here and he asked me if I would read the report. Of course I was glad to do it.

Subcommittee No. 4 was assigned jurisdiction over approximately half of he $333,070,000 authorization requested for the 1960 fiscal year for research and development by the National Aeronautics and Space Administration. In accord with this, the subcommittee held four meetings on April 24 and April 27, including three open and closed hearings, at which it heard NASA officials testify on requests for funds for space propulsion technology, space systems technology, supporting activities, and vehicle development.

The subcommittee voted unanimously to recommend to the committee approval in toto of the $167,800,000 requested by NASA in these research and development programs.

In doing so, the subcommittee was cognizant of the fact that some of the programs carry commitments that will necessitate the authorization in the future of still additional funds if the programs are to be completed. There was considerable discussion and questions were raised concerning the advisability of the $8 million authorization for the development of nuclear-powered systems, a program in which the Atomic Energy Commission is also participating.

The same held true for the Sentaur program, involving the development of a general-purpose space flight vehicle, which will be used for communications satellites, and for a soft landing on the moon.

NASA is requesting $41 million for this program for the 1960 fiscal year. The program will require the funding of another $32.5 million in fiscal years 1961 and 1962, and will cost an estimated $95.5 million, including $22 million committed by the Defense Department, which is transferring the program to NASA next July 1.

NASA witnesses, headed by Dr. Abe Silverstein, Director of Space Flight Development, assured the subcommittee that the funds were not being programed prematurely. They investigated the long lead-time involved in the development of these and other space programs. Thus, the first Centaur vehicle will not be launched until 1961, while the 1-million pound thrust single chamber engine, which will cost an estimated $102 million to develop, will probably not be completed for 4 years.

The subcommittee realizes the importance of exercising economy, especially in programs which will apparently prove very costly. But it realizes also the necessity of forging ahead in this very important field of space development and space exploration. We must not lose sight of the fact that the United States is not yet foremost in this field and that great effort and money will have to be expended if we are not to fall behind—much less catch up and surpass other countries.

The security of the United States and the free world may well rest upon the effort expended and the money authorized for space development and exploration. As laymen in this field, we must rely to a great extent upon American scientists and technologists to chart for us the fields that we must explore.

In reliance upon their judgment and convinced of the need of pushing ahead in astronautics for the fullest possible speed and the greatest effort possible, the subcommittee has approved the authorization requested by NASA. They include: $52,200,000 for space propulsion technology; $5 million for space systems technology; $11,500,000 for supporting activities; and $99,100,000 for vehicle development, or a total of $167,800,000—$333,700,000 being requested by NASA for research and development.

I might note in passing that the authorizations here are in line with the President's budget and were approved without change by the Bureau of the Budget before they were submitted to Congress.

I move the adoption of the report, Mr. Chairman.

Mr. McDonough. I second that motion.

The Chairman. That is a good report, too. Mr. Fulton.

Mr. Fulton. On your statement that the United States is not yet foremost in this field, I believe that has within it the context that the

United States is further ahead in some portions of the field, while other people may be further ahead in other portions.

I think we do have an adequate program going, and in some fields there is not any way for anybody to tell who is ahead or who is behind.

Mr. HALL. I think we know from the testimony that has been given, Mr. Fulton, that we are not ahead in the pure propulsion part of the field.

Mr. FULTON. But we are probably ahead in guidance and control.

Mr. HALL. That has been suggested by the witnesses here, but they had no way of knowing.

Mr. FULTON. Communications and things of that type. So, with those exceptions, I think that statement is very fine and I would be glad to approve it.

The CHAIRMAN. You have heard the motion to approve the subcommittee report. I think it is an excellent report.

All in favor make it known by saying "aye."

(Chorus of "ayes.")

The CHAIRMAN. Those opposed?

(There were none.)

The CHAIRMAN. It is unanimously approved. We certainly thank you. The committee thanks the chairman, who is not here today and who asked that this be taken up in his absence.

Mr. FULTON. May we also add our thanks to the acting chairman as *well, Mr. Chairman—Mr. Hall.*

The CHAIRMAN. We didn't want to overlook Mr. Hall, I will tell you. I think he always does a creditable job.

Mr. Ducander, what is the report on Mr. Miller and his subcommittee?

Mr. DUCANDER. We have the report.

The CHAIRMAN. We can take it up here if you have the report. When did Mr. Miller say he would be able to be down here?

Mr. DUCANDER. He expected to be here now.

The CHAIRMAN. Could you give him a ring and tell him we are going ahead. We are making such good progress that we have gotten to his committee. Who was the staff member?

Mr. DUCANDER. I was, Mr. Chairman.

The CHAIRMAN. Could you give us a general report on the number of sessions and witnesses and a few things of that sort? Don't try to steal the committee's report, however.

Mr. DUCANDER. We had one session on Friday afternoon of about 2 hours' duration. We had four witnesses, headed by Mr. Abbott.

The jurisdiction of Subcommittee No. 1 was to look into the construction and equipment items of the bill. The committee has approved six items and have sent one item back to the full committee for decision which they did not wish to approve.

The CHAIRMAN. So six out of seven have been approved?

Mr. DUCANDER. Yes, sir.

The CHAIRMAN. It is the view of the senior Democrat on the committee—you have got a copy of the report?

Mr. QUIGLEY. I do, Mr. Chairman. In light of the fact there is one item that the subcommittee is reporting back for action by the full committee. I would hope that the chairman could be here.

Mr. FULTON. If you had the staff explain to us that one item that was not approved, just explain the background of it so we know ahead of time——

The CHAIRMAN. Yes, so you won't lose the time here while we are waiting on Mr. Miller.

Mr. DUCANDER. I understand he is not in his office. He is not back from his engagement yet.

Mr. QUIGLEY. Mr. Chairman, in that event I would be perfectly willing to read the report and then go ahead.

The CHAIRMAN. Go ahead and do that. Then we will hear from Mr. Miller when he does come in.

Mr. QUIGLEY. Mr. Chairman, Subcommittee No. 1 met, as Mr. Ducander has indicated, last Friday afternoon to consider the construction and equipment provision of H.R. 6512 in accordance with your direction. The subcommittee unanimously approved without amendment the following items in the bill:

1. The Langley Research Center at Hampton, Va., $4,580,000.
2. The Ames Research Center at Moffett Field, Calif., $6,555,000.
3. The Lewis Research Center, Cleveland, Ohio, $6,850,000.
4. The High-Speed Flight Station at Edwards, Calif., $2,805,000.
5. The Beltsville Space Center at Beltsville, Md., $14 million.
6. The Pacific Missile Range in California, $3 million.

You will note that the seventh item of construction and equipment appears on page 2, line 23. This is entitled, "Various locations." The subcommittee approved the amount of $10 million as it is being requested by NASA for global range tracking and communication facilities and equipment. The subcommittee also approved facilities for the Rover program in the amount of $2 million.

The final item in this provision in the bill is for propulsion development facilities and totals $8 million. This consists of a requested authorization to construct two captive test stands in order to test the development and flight readiness of the new Vega and Centaur second stages. These test stands would cost $1,500,000 for the Vega captive stand, and $1,750,000 for the Centaur captive stand. Both of these items were approved by the subcommittee.

The other portion of this item for propulsion development facilities is for the construction of a central facility for high-energy solid and liquid rocket propellant research in the amount of $4,750,000. The subcommittee was told that this new facility is necessary to permit an accelerated research and exploration development of rocket engines that use high-energy liquid propellants.

Many of the high-energy propellants such as fluorine are extremely caustic, corrosive, and reactive. As a consequence, current research facilities such as the Lewis Research Center and the Jet Propulsion Laboratory are severely restricted in their testing of these propellants because of their proximity to urban areas. Therefore a specialized facility located in an isolated area is required.

However, the subcommittee learned that no site had been selected for this facility, but NASA has nonetheless budgeted certain amounts for site preparations—roads, fencing, and a water system—totaling more than $2 million.

The subcommittee therefore took no action on this portion of the authorization for propulsion development facilities because it is hard

put to understand why the Congress should authorize funds for such items as site preparation, roads, and fencing for a site which has not yet been selected. Two courses of action seem apparent to the subcommittee.

First, this committee could delete the funds which NASA is requesting for this facility and insert a provision in the report recognizing the need for the facility and express our willingness for NASA to come back for a supplemental authorzation when the site for the proposed facility has been selected and the budget request can be based on actual estimates rather than imaginary ones.

The second course would be for the committee to approve the request for this facility, but make it clear in the report that the budgetary request was based on a minimum estimate derived from experience gained from construction of like facilities in the past.

The subcommittee therefore has approved all the items of construction and equipment—save and except provisions for propulsion development facilities—in the amount of $4,750,000.

The CHAIRMAN. A very fine report. It shows a lot of attention to your problems.

Mr. Teague.

Mr. TEAGUE. Was there any indication that they would select that site any time soon?

Mr. DUCANDER. I can answer that, Mr. Quigley. They said they are appointing a committee to meet to go over various sites and that this committee would then recommend a site. But they said the committee had not met and didn't anticipate they would meet for a month or two.

Mr. TEAGUE. Is there a question as to whether or not the failure to appropriate this money would delay the project?

Mr. DUCANDER. They say it would.

Mr. QUIGLEY. I think the subcommittee kind of felt the cart was before the horse at this stage—perhaps not.

Mr. DUCANDER. I can point out this is in the backup books on page 397. You will see there what they are asking for this central facility for high-energy solid and liquid rocket propellant research.

In the first place, you see that they are asking for roads and fencing, $600,000. The subcommittee couldn't get out of them how they arrived at a $600,000 item for roads and fencing when they didn't even know where the site was going to be.

How can you tell how many roads or how much you are going to have to spend on roads or fencing when you don't know where the site is going to be? The same was true of site preparations, grading, drainage, and trenches, $300,000; and a water system, 1 million gallons per day, $600,000.

Mr. FULTON. The answer to it is that, even with a month's time for the appointment of a committee for consideration, there would still be time in this session of Congress for us to act.

Mr. DUCANDER. That is what the subcommittee thought, Mr. Fulton.

Mr. FULTON. May I make the motion that the subcommittee report be approved.

Mr. HECHLER. There is an alternative.

Mr. FULTON. Then we will take the motion up as to what to do.

The CHAIRMAN. Let's hear the alternative.

Mr. HECHLER. There are two alternatives presented.

Mr. FULTON. Again, the point I am making is we don't decide that until a separate motion comes after we approve the report.

Mr. HECHLER. I yield to the gentleman on that point.

The CHAIRMAN. You have heard the motion to approve the report as rendered. All in favor make known by saying "Aye."

(Chorus of ayes.)

The CHAIRMAN. All opposed?

(There were none.)

The CHAIRMAN. The ayes have it unanimously. I want to say this. I know Mr. Miller has worked very hard on this report and on the hearings. I want to commend him and the men who have reported to the full committee for the fine work they have done in this respect.

What are your alternatives, Doctor?

Mr. HECHLER. There are two alternatives presented on page 2 of the report, in the report itself, which are:

No. 1, the committee could delete the funds; or, No. 2, the committee could approve the request but make it clear in the report that the budgetary request was based on minimum estimates arrived at through experience gained in constructing like facilities in the past.

It would seem to me personally that it is highly premature for this committee to authorize the expenditure of these funds which are based on rather imaginary considerations, since the site hasn't yet been selected. I don't see how this would be any serious delay in carrying forward this program.

I would like to make a motion that the full committee accept the first of the two alternatives.

Mr. FULTON. I second that motion.

The CHAIRMAN. What is that?

Mr. HECHLER. This committee delete the funds which NASA is requesting for this facility and insert a provision in the report recognizing the need for the facility, expressing our willingness for NASA to come back for a supplemental authorization for the site when the proposed facility has been selected and the budget request can be based on actual estimates rather than imaginary ones.

The CHAIRMAN. What was done in that respect by the Senate, Mr. Ducander?

Mr. DUCANDER. The Senate hasn't taken up the line items yet, Mr. Chairman.

Mr. QUIGLEY. Mr. Chairman, may I be heard in support of Dr. Hechler's motion that we adopt the first alternative? I really don't believe that we are delaying or hindering or harming the program by deleting this particular item. From the point of view of defending this bill on the floor, this is the kind of item that can make the committee look awfully ridiculous when you are putting up a fence and you are putting in roads and you are spending millions of dollars on a water system and you don't know whether it is going to be in California, New York, New Mexico, or anywhere else.

It is just one of those points I think could be used against us. I think we would be much better off if we deleted the item, with the full understanding on the part of everybody concerned on the committee and in NASA that when, as, and if, the time comes the committee will immediately act with speed. So, as a result of our action

in deleting this item, we won't harm or hinder the program or delay it in any way.

The CHAIRMAN. What do you think of this as a suggestion to you gentlemen? The chairman of the subcommittee is not present. I would like to have him present when we act on that. That is the only item in controversy in the whole bill as far as the subcommittees are concerned.

We have to read this bill. What do you think of postponing actual decision on that until we read the bill and then take that one item which is in controversy up at the last and dispose of it?

Mr. FULTON. May I ask a question. What does the chairman of the subcommittee say about this alternative? Which one does he favor?

Mr. DUCANDER. I think he favors the first one, although the subcommittee felt that this was a matter that should be referred back to the full committee.

One other thing, Mr. Chairman. The Appropriations Committee are starting hearings today on this bill. I am sure they won't report any appropriations bill until this bill has cleared the House; but at the same time they are going to have these backup books just like this committee. I think the subcommittee was reluctant to go ahead and authorize this and then have the Appropriations Committee catch it and say, "Well, that committee down there is just authorizing this stuff just like this, and we have to catch it."

Mr. HECHLER. Mr. Chairman?

The CHAIRMAN. Mr. Hechler.

Mr. HECHLER. In view of the fact that the chairman of the subcommittee leans toward approval of the first alternative, I would like to renew my motion that this committee adopt the first alternative and delete the funds.

Mr. MCDONOUGH. Mr. Chairman.

The CHAIRMAN. Mr. McDonough.

Mr. MCDONOUGH. During the discussion on this item, was there any information obtained as to the use of existing captive test sites that are either now under lease—I don't know whether we own any or not, but we are leasing some.

Mr. TEAGUE. There are some at Redstone.

Mr. MCDONOUGH. Redstone. And there are captive sites at Rocketdyne out in California.

Mr. DUCANDER. I questioned the witnesses on this, Mr. McDonough, and asked them, for instance, why they couldn't use Cape Canaveral or some places on the Pacific missile range or something like that. They say that this particular site must be away from urban population; that this fluorine they intend to use has a bad effect on people who are around it. Therefore it must be away from something or away from urban population.

They say in addition, they are not going to go out and buy any land. You will notice here on page 397 there is no item in here to purchase any land. They are going to try and use some facility, a military facility or someplace at least, that has Government-owned land where they won't have to spend any money on the land. I think that is commendable. At the same time they have no idea at this time where this site is going to be.

Mr. McDONOUGH. Rocketdyne is pretty well isolated, as far as that is concerned, from any urban community.

Mr. DUCANDER. It might very well be, then, they would select that site.

Mr. McDONOUGH. Or Point Arguello, the Pacific missile range, is to some extent isolated, although it is closer to an urban area.

Mr. DUCANDER. Apparently they had no idea at this time where they wanted to put it. The committee had not met.

The CHAIRMAN. I will say this, I thought we had a lot of experience with these things, too, in the past. It is difficult at the best. I would like to see in this bill a provision worked out for this organization to report back to this committee at the proper time following the action of their committee on the location of the site they have recommended and expect to use. I think that is fair to do it.

Otherwise we are going to find that we have lost control and that another committee of Congress is locating the site. That is the reason I suggested we wait until the chairman of the subcommittee arrive—now he is here; we are happy to have him—or perhaps until the time of reading the bill, and work out an amendment which would require the committee to report back to this committee as to the location which they had determined upon

Mr. ANFUSO. I agree with that 100 percent.

Mr. FULTON. Would you yield on that point?

The CHAIRMAN. Yes.

Mr. FULTON. I would like this committee to act so this is not done first by the Appropriations Committee and then we just accede to it.

The CHAIRMAN. That is exactly my point.

Mr. FULTON. So I really would resecond my second of the motion of Dr. Hechler that we at this time have an action setting it aside by this committee, and then whenever the Appropriations Committee acts, they already have seen the way pointed by this committee.

I don't believe I would put this decision off until the Appropriations Committee has their hearings today or tomorrow and then we find that they have cut it out and we are just acceding to the authorization.

The CHAIRMAN. You didn't mean when you said they were having the hearings today or tomorrow that they are going to dispose of this matter?

Mr. DUCANDER. No, not that they will dispose of it.

The CHAIRMAN. I think our bill will be out and through the House before they dispose of it.

Mr. FULTON. That's right. But of course they make the recommendations among themselves and it gets around the House they have already knocked it out. So that, formally, you are correct; but practically I would like this committee to act first.

The CHAIRMAN. What we want to do is to retain the leadership and if we don't write something in this bill that retains the control of the location, we are going to lose to another committee. That is all. Armed Services always does that, as Mr. Miller will tell you. It is simply to write a provision in the bill that when this committee goes out, that it give us a report before they finally confirm the decision of their own committee as to the location of the site.

That is reasonable. We are an authorizing committee. We are not able to select the site. We don't want the job of selecting the site. But we want to know where it is going to be so no other committee can write into the law that this location is as follows.

Mr. HALL. Mr. Chairman?

The CHAIRMAN. Mr. Hall.

Mr. HALL. May we hear from Mr. Miller?

The CHAIRMAN. Mr. Miller.

Mr. MILLER. Mr. Chairman, I want to apologize for being late, but I have been engaged on a very important matter affecting the San Francisco Bay area, a hearing before the Civil Aeronautics Board, and my colleagues are down there. I got here as quickly as I could.

The thing that we were concerned with in the subcommittee was the fact that this was not a definitive proposition. They were asking for money or asking, in effect, for a blank check.

We haven't too many facilities for judging at best what an agency such as this is doing with its money, but I think we would be in for a great deal of criticism if we pass authorizations that aren't definitely set up and cannot be justified.

I appreciate the emergency, and Dr. Abbott and the others who appeared before us tried to impress on us the urgency of this matter and to approve it. But if we take it out of the budget and write into the report definite language, recognizing the necessity for it and assuring that if and when they select this site they can either bring it in as a separate bill, that it will receive immediate attention, surely there are enough funds due here that under their flexible setup they can start some of their work once we approved the thing; and there are always supplemental appropriations coming along so that they are not going to be delayed too much.

I personally do not want to see this committee criticized by other committees of the House or by the House itself as being irresponsible in fiscal matters. We are going to have enough to justify to the House, because this is an experimental field and money is spent. Charges can be made that it is wasted. We have got to defend all of that because we have confidence in these people.

But I think when it comes to acquiring property they presume a little bit when they come in here and ask us to give them a blank check in a thing of this nature.

Mr. HECHLER. Mr. Chairman?

The CHAIRMAN. Mr. Hechler.

Mr. HECHLER. I would appeal also to my colleagues on the positive side, that when there is an opportunity to save some money, that we not resist the urge.

The CHAIRMAN. This is postponing it.

Mr. ANFUSO. Mr. Chairman?

The CHAIRMAN. Mr. Anfuso.

Mr. ANFUSO. Mr. Chairman, I don't know the exact procedure, but is it possible to induce NASA not to submit this portion to the Appropriations Committee, depending upon our promise that it will be submitted in the report?

The CHAIRMAN. We can't control what they do. The way we can do it is by proper authorization. If there is no objection, we will vote on the motion and then I will get Mr. Ducander to prepare an amendment which we can consider when we read the bill.

Mr. ANFUSO. We are voting on your motion?

The CHAIRMAN. No, the committee's motion. Take the alternative, and then we will prepare an amendment which we will consider when we take up for reading the bill.

Mr. MCDONOUGH. And the Appropriations Committee will then know what the action of this committee is when they consider that item.

The CHAIRMAN. That's right.

Mr. DUCANDER. There will just be no authorization for it, so they won't be able to take it up.

Mr. MILLER. They can't take any action because they would be up for criticism if they took action and appropriated this money in view of our action.

The CHAIRMAN. You have heard the motion. All in favor make it known by saying "Aye."

(Chorus of "Ayes.")

The CHAIRMAN. Those opposed?

(There were none.)

The CHAIRMAN. The ayes have it and the motion is carried.

Mr. Ducander, give that thought. I think the important thing is voting on the amendment when it is prepared.

Mr. FULTON. Mr. Chairman, I think the record should show that that was carried unanimously.

The CHAIRMAN. If there is no objection, it will be proclaimed as being unanimous there.

That brings us to this point, that all of the subcommittee reports have been approved by the full committee, and I think that is wonderful that we are able to approve every one of them, and every one unanimously, too. Mr. Miller wasn't here to get his part of the glory during the reporting, but we did wait as long as we could.

Mr. MILLER. I appreciate that.

The CHAIRMAN. The House goes into session today at 11 and we don't have authority to sit after it goes into session.

Mr. MILLER. I would like to thank the members of my subcommittee. They did some very good work and it was very encouraging and rewarding.

The CHAIRMAN. Fine. All of the subcommittees did a great job and we appreciate it.

Because of the fact that the House will be in session in another moment or two, we will adjourn until probably Monday morning and we will read the bill at that time.

If there is no objection, we will stand adjourned.

(Whereupon, at 11 a.m., the committee adjourned.)

1960 NASA AUTHORIZATION

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
Washington, D.C., Monday, May 4, 1959.

The committee met, pursuant to notice, at 10 a.m., in room B–214, New House Office Building, Hon. Overton Brooks, chairman, presiding.

The CHAIRMAN. I think we can start the hearing this morning. The committee will come to order.

Leave the door open. This is an open session. I think we can start.

We have one thing that we want to hear Dr. Glennan on in reference to H.R. 6512.

Since there are a number of matters of a purely business nature—like, for instance, we have two reports here to consider, and we have the reading of the bill, as well as some other matters. I think then following the hearing of the testimony we can go into executive session and complete the committee business and perhaps all of it this morning.

Now, at my suggestion, we invited Dr. Glennan to come back here and give us any additional light that he can on the question of this particular base or installation to be located someplace in the United States.

We received a committee report and the committee has approved the report. Since Mr. Miller handled this in the subcommittee, I thought I would like to have him take the lead in asking questions following your statement, Dr. Glennan.

Will you tell us again about this particular location? Why, for instance, did you ask for funds for landscaping and roads and all of that when you had not located the installation and consequently could not, as a matter of fact, know what was needed in the way of money for roads and landscaping, fencing, and things of that sort?

The committee would like to know this. We don't want to be unfair. At the same time, we want to be able to go to the floor of the House with a bill that we can defend, and not one that would be ludicrous.

So if you would be willing to go into that again, Doctor, we will appreciate it.

STATEMENT OF DR. T. KEITH GLENNAN

Dr. GLENNAN. Thank you very much, Mr. Chairman.

I think in this particular situation we may have attempted to delineate segments of the total cost of this proposed facility in detail which was not justified by the detailed planning which would be required in order to get to these figures.

But there are certain extenuating circumstances which I am pleased to have a chance to talk to the committee about.

Before I do that, I wonder if I might ask Dr. Dryden to express very briefly the need for this type of facility as we move forward in this program, looking toward the development of higher specific inpulse fuels—so-called exotic fuels—in a national development program.

Dr. DRYDEN. Mr. Chairman, very briefly, this facility was to provide the opportunity for doing research on advanced propellants. The immediate problem is of such substances as hydrogen and fluorine at sizes somewhat larger than those that we can do at current installations, and we foresee the need for a remote type of installation; that is, an installation in which no hazard is introduced to a community by the use of these very toxic substances.

At the present time we do research on a very minute scale in this area in our laboratory at Cleveland. We do research at a somewhat larger scale at facilities at the Plumbrook Arsenal, which is the site for activities that require a lot of area around them, including our nuclear reactor installation.

These, however, are still on a relatively small scale and, as we proceed to sizes which are of more interest for actual use, it will be necessary to develop another national site.

At the same site research could be done on advanced solid propellants as well.

We want to make it very clear that this is the beginning of a national research facility.

It differs from the facilities used in development in that this is a place we make experiments. Perhaps we take somewhat more chances than we would be willing to do on an engine development because we want to get new knowledge.

We estimate that there might be as much as $20 million expended on such a site over the period of the next 4 or 5 years. We have not selected a site. We have had available to us, as I think we mentioned in the testimony, some studies made by other agencies. One by the Air Force, in looking into the possibility of a location on the Edwards Air Force Base, and another study which had been earlier made by JPL under Army auspices of the Goldstone Lake region in California.

We have established a site committee of our own. We are engaged in formulating the specifications which the site will have to meet; I think I have covered the earlier part.

Dr. GLENNAN. Now, Mr. Chairman, I am glad that Dr. Dryden pointed out that this is in the nature of a national facility that we are talking about.

I think you are all aware of the fact that in the development of propulsion systems, rocket engines, and that sort of thing, one finds it necessary from time to time to provide at contractor-owned facilities some Government-furnished test facilities for development purposes.

But this is in the field of advanced research and development and we would like to think of this as a national center, where people from our laboratories, from the Jet Propulsion Laboratory, and perhaps from some of the Air Force contractors or the contractors to other services, or industrial companies, can come to use a facility which is solely located as to avoid the possibility of contamination when we are using these highly toxic fuels.

As to criteria, one might cite some of these as important:

The isolation from centers of population.

Proximity, however, to the user, if possible. And this is a little bit difficult when one looks at it as a total national facility. So we say that actually we are going to look everywhere we can in the United States, hopefully at Government-owned land, however, so we don't have to buy some more land and take it out of circulation.

We ought to look, if possible to a site where there are available administrative services, so again we don't have to duplicate existing services. We ought to have available the kind of utilities in the quantities we need—particularly power and water.

Accessibility where one has to take highly toxic propellants and fairly sizable pieces of hardware to the test site.

Now, to get to the actual figures given in support of the $4,750,000, I suppose in engineering terms one would call this an extrapolation of the figures or perhaps even an interpretation of the figures developed as estimates by the Air Force or by Jet Propulsion Laboratory and by a group from our own Lewis Research facilities in looking at some of these other sites, which would be typical sites.

So the individual items here are really extrapolations of estimates made for other sites; that is, sites which in the case of the Edwards site, was a total cost of $8.7 million. The Goldstone site, a total of $9.8 million. And we pulled these back into a facility which we think will do the job we need to have done in the course of the next 2 or 3 years, at a total of $4,750,000.

We probably would have been better off, I think, Mr. Chairman, if we had simply said to you in other estimates the breakdown for particular items of cost ran in these general proportions.

We think we are going to have to have a site which is going to cost us about $5 million and just leave it to you, because we really have to have this kind of a facility.

The CHAIRMAN. As I understand, this is a Government-owned site?

Dr. GLENNAN. This will be a Government-owned site.

The CHAIRMAN. It is already owned by the Government?

Dr. GLENNAN. Yes, sir.

The CHAIRMAN. But you haven't selected it?

Dr. GLENNAN. That is correct.

The CHAIRMAN. And you feel now that it would have been, had you not recommended a sum for fencing and grading and——

Dr. GLENNAN. We might, sir——

The CHAIRMAN. Utilities and all of that sort?

Dr. GLENNAN. We might better have listed these items as the items which would have had to be included in an estimate, but not given you final figures for them because the site itself had not been selected.

Mr. MILLER. Mr. Chairman.

The CHAIRMAN. Mr. Miller.

Mr. MILLER. Doctor, I have perfect confidence in your figures. I don't think anyone questions the necessity for this installation.

The question did arise in the subcommittee as to whether we should approve a project that was based on these estimates and for which no location has, as yet, been approved.

In effect, this is the first bill of this kind that comes before this committee, and we have to determine a policy. Is the committee going to give the agency a blank check on projects of this kind? In

effect, that is what we are doing. We are saying, "We realize it; here it is, and there is not a great deal of money involved here, compared with the other expenditures."

This principle is one that has not met with much favor. As a matter of fact, a great deal of criticism has been made of the Appropriations Committee.

We say to you, "Here is a blank check." The Appropriations Committee then challenges us and says, "Well, what do you do? Do you just take this?"

"We will take charge of this matter and then we will write the regulations into law."

And we invite the bypassing of this committee on approvals of this nature.

Now, I pointed out at the time to Mr.—Atkinson, was it?

Mr. DUCANDER. Abbott.

Mr. MILLER. Mr. Abbott, that there will be—we have the majority leader here and we have the man on the other side, of long and great experience. I say there will be most likely two supplemental bills passing this House before the Congress adjourns. I have never seen it fail yet.

Mr. MARTIN. At least two.

Mr. MILLER. At least two.

If you can come in with a site and show us where you are going to locate this and then tell us what these facilities are going to cost, I see no difficulty whatsoever in getting this included in a supplemental bill.

Dr. GLENNAN. Mr. Miller——

Mr. MILLER. Now, that is the position that the committee took. It does not question the figures that you submit here as being typical if they are located on a Government site. You haven't been able to locate that site as yet. Perhaps you haven't had too much time to look for it.

Assuming that it is located on a Government site, this is what it is going to cost. Assuming you can't find a governmental facility that is willing to take this as a tenant then—you have to come back anyway because the amount of money you have asked for isn't going to be sufficient to purchase a site or acquire a nongovernmental site. And yet the necessity for this thing is going to be just as great in that case as it is now.

The subcommittee recognizes the necessity. It recognizes that the figures that you submitted here are reasonable figures. They balance out.

But the question of whether we should approve a project in advance and lay ourselves and not only ourselves, but may I point out, sir, the agency in a position of being criticized by other segments of Congress was one that we thought we would rather leave to the full committee, and that is the burden of our report. The burden of the report in no way reflects on NASA. It has just asked the full committee to determine what its policy is going to be, and in asking that determination it recommended that this be not approved until you could give us the factual data and you have selected a site.

The CHAIRMAN. Let me ask Dr. Glennan one thing.

Now, the sum of $41\frac{1}{2}$ million is involved in this; isn't it?

Dr. GLENNAN. Yes, sir.

The CHAIRMAN. That is the rest of the $20 million—the rest of the $20 million is for other projects that have been supported and approved by your subcommittee.

Mr. MILLER. That was approved. The only thing we held up was the $4,700,000.

The CHAIRMAN. Fine.

While you are here, Doctor—I understand the doctor agrees with the subcommittee on the matter.

Let me ask you, Doctor, while you are here, you made a change in your program as a cancellation of the Venus shots.

Will you need the money that you are asking for the R. & D. program for the Venus shots?

Dr. GLENNAN. Yes, sir, Mr. Chairman. These shots were not canceled. They are simply postponed until the technical difficulties can be surmounted.

The CHAIRMAN. There won't be any change in expenditures then?

Dr. GLENNAN. I think this is quite right. There won't be any cancellation.

The CHAIRMAN. So the cancellation will not save us any money?

Dr. GLENNAN. No, sir; and it is not a cancellation. I want to point out that clearly. All we are losing in not being able to shoot them at the time of Venus, of this particular propitious, of a shot toward Venus, is the possibility that we might have come close to Venus, and learned something about the atmosphere or lack of atmosphere in the vicinity of that planet.

These last deep space probes will return to us very, very much information, and we will reprogram those in another manner.

Mr. QUIGLEY. Mr. Chairman, would the chairman yield for a question at this point?

The CHAIRMAN. Mr. Quigley.

Mr. QUIGLEY. Doctor, if you do not shoot them on schedule—which I believe was roughly June——

Dr. GLENNAN. Yes, sir.

Mr. QUIGLEY. When would be the next appropriate time?

Dr. GLENNAN. Just as soon as we could clear—the next appropriate time for Venus? It will be about 15 or 18 months later, as I recall, in January of 1961, is it not, Dr. Dryden?

Dr. DRYDEN. Yes.

Mr. QUIGLEY. Now, in that extended period, are you likely to need less or perhaps even more money for research and development in this area?

In other words, the chairman suggested that perhaps it would save us money by reason of the postponement.

The CHAIRMAN. In the fiscal year, I thought perhaps it might.

Mr. QUIGLEY. Perhaps the other side of it—you might need more.

Dr. GLENNAN. If we decide to make further attempts at Venus in 1961, we may need more money, certainly in the 1961 budget.

Mr. QUIGLEY. But not in the 1960?

Dr. GLENNAN. Not in 1960.

Mr. QUIGLEY. Thank you, Mr. Chairman.

Mr. SISK. Mr. Chairman——

Dr. GLENNAN. Mr. Chairman, I would like to—excuse me, sir.

Mr. SISK. If the doctor has a further statement, go ahead.

The CHAIRMAN. Have you a further statement, Doctor?

Dr. GLENNAN. Yes, sir.

If I may, and speaking to some of Mr. Miller's comments, I am indeed——

Mr. FULTON. Mr. Chairman.

The CHAIRMAN. Let him finish his statement. I thought he had finished. When you are concluded, we will yield to Mr. Fulton.

Dr. GLENNAN. Excuse me.

I simply wanted to be responsive to a comment of Mr. Miller's if I might.

I am glad, of course, to have the subcommittee accept the reasonable——

The CHAIRMAN. Doctor, would you speak up just a little louder so we won't have as much trouble hearing you?

Dr. GLENNAN. I am very glad——

Mr. MILLER. Some of us are World War I veterans, Doctor.

Dr. GLENNAN. Yes, sir. The subcommittee accepted the reasonable validity of these estimates as something that is really within the ball park, but the proposal that we operate on the basis of going the route of a supplemental does give me some concern.

As I read that proposal, it would mean essentially a delay of about a year in getting on with this particular job.

I have been very much impressed with the expressed desires and the actions of this committee in helping us get on with this job, just as fast as we can.

It will take perhaps 4 to 6 months to pick this site. By that time the Congress will be out of session. We will be coming back with a supplemental in January of 1960, and here it is May and this supplemental, the supplemental presently before the Congress will not be probably in our hands until July of this year.

So we are looking fully a year ahead and perhaps longer, if we go that route.

I think there is no question at all that we would be very happy to come back to the committee and tell the committee of the selection of the site at the time that that had been accomplished.

This is not an attempt to get a blank check, sir.

Mr. MCCORMACK. What other journey can you take though? You have to go through the Appropriations Committee.

Dr. GLENNAN. We would hope that the Appropriations Committee would approve this—the inclusion of this facility, if the authorization committee here would approve it.

Mr. MCCORMACK. In other words, you want an authorization without the selection of a site?

Dr. GLENNAN. The selection of site to be reported back to this committee.

The CHAIRMAN. What you would like to have would be the authorization——

Dr. GLENNAN. To proceed.

The CHAIRMAN. With a stipulation written in the bill that you must report the selection of the site back to the committee before proceeding with the authorization.

Dr. GLENNAN. I would be perfectly willing to do this.

Mr. MCCORMACK. Of course, that puts the committee in a very difficult position, you know. We are originally legislating, Doctor. When we have this report, we lose our original jurisdiction. We are well acquainted with just reports.

If you say you have to speed the approval of the committee and we have a veto, why that is different. Yet the question of whether that is constitutional or not remains. Then you encounter difficulty in getting that through. We have had that experience.

The only way you can get it is a direct debt transaction, and you couldn't get it in legislation of this kind. I doubt it very much.

Dr. GLENNAN. Well, may I throw myself on the mercy of the committee? I am a neophyte in this business. How then does one go about getting ahead with this kind of a job when there simply hasn't been time to get all of these things done and yet you know this must be done?

The CHAIRMAN. Why can't we authorize the appointment of your committee to make selection of sites and urge that you speed it up and advise us?

Dr. GLENNAN. The committee has been appointed. They are in existence, working.

Mr. FULTON. Why can't you come back to us later in the current session and say to us what you have done and if you were then up to the time where you need an authorization, I am sure this committee would give it very careful and probably favorable consideration.

But I would agree with the majority leader that at this particular time it does put this committee in an embarrassing position to say the least, and probably an unconstitutional position. If you come back later for an authorization, it can be acted on within the very day you come. You will keep us advised what progress is being made.

Mr. MILLER. I am sure if you could give us—will you yield?

Mr. FULTON. I will be glad to.

Mr. MILLER. If—you could give us the information at any time, and I am certain it won't take the committee to clear it more than the day you come up.

If there is a supplemental going through, we can perhaps get it in that supplemental, and perhaps even up to the last minute.

Mr. MCCORMACK. I wouldn't put the burden on the committee to get it in the supplemental. Put the burden on the Doctor.

Mr. MILLER. We can offer an amendment if necessary.

The CHAIRMAN. Well, of course, they have to come back at a time when the Congress is in session because we couldn't do it while Congress is adjourned.

Dr. GLENNAN. Well, Mr. Chairman, this means—if I understand it correctly—that if this were set aside with the idea that we were to come back when we had this site selected, hopefully in this session of the Congress—and I am not sure that this can be done. It is not a simple matter to meet the criteria that we are talking about here. Then we would have to go back through the Appropriations Committee again. They probably having acted on the bill which would have been reported out by this committee; is this not right?

Mr. MILLER. No.

Mr. MCCORMACK. No.

The CHAIRMAN. No, they would have probably put up the money as authorized by H.R. 6512 in the meantime, yes. But we would go back for a supplemental request.

Mr. MCCORMACK. Will you yield there?

The CHAIRMAN. I yield to the distinguished majority leader.

Mr. MCCORMACK. After we pass the authorization bill, Doctor, the burden is on you to get the budget estimates sent up. The Appropriations Committee doesn't pick up these bills and appropriate. There has to be a budget estimate. That has to initiate in the executive branch.

So if your impression is that just because a committee passes a bill that the Appropriations Committee then starts appropriating on it—in practical operation that is not the situation. There have to be budget estimates.

Dr. GLENNAN. Well, we are supporting this budget estimate to the Appropriations Committee at the present time.

Mr. MCCORMACK. You see, a clearance of the budget for authorization purposes is one thing. The clearance of a budget for appropriating purposes is another thing.

Mr. SISK. Mr. Chairman.

The CHAIRMAN. Mr. Sisk.

Mr. SISK. Dr. Glennan, I would like to ask you a couple of questions now. In my subcommittee, at the time we discussed our portion of the R. & D. program, we discussed at some great length the Vega and Centaur program.

As I understand this particular site has to do with work, experimental work and so on on the Vega and Centaur program.

Dr. GLENNAN. No, this is not correct, Mr. Sisk.

Mr. SISK. In other words, I must be looking at the wrong item then.

Mr. MILLER. The item is 395.

The CHAIRMAN. 397.

Mr. MILLER. 395. The item commences and runs through that section. The last one in the book—propulsion development facilities, and it is only part of that $8 million. It doesn't include all of it. It only includes part.

Mr. SISK. All right. In other words, the Vega captive stand and the Centaur captive stand are not included in the figure?

Mr. MILLER. That is right.

Mr. SISK. The reason I wanted to ask these questions is, of course, in our consideration of the $170 million, approximately $170 million, which was that portion of the budget assigned to the subcommittee, these variance programs received quite a going over.

Frankly, I realize that we had to accept them on faith because we do have confidence in you people. But I was curious to determine as much as is possible about how many other items included in this budget might be tied in to these particular programs.

I asked the question because, of course, on Vega we have—that is, we recommended to the full committee an authorization for $42,800,000 on Vega and $41 million on Centaur.

As I understand it, in the 1959 budget you had approximately $22,800,000. Now, I get a total on those—we have something over $106 million on those two figures, and I was curious to know how

many other items in this budget are connected with those two programs; that is, those two vehicle programs.

Dr. GLENNAN. Just these two stands, Mr. Sisk.

They are to be located near the contractor's plant at Sycamore Canyon. They are the developmental test stands for both the Vega and the Centaur. These are independent of this national propulsion facility we are talking about.

Mr. SISK. I see, and the site has already been selected?

Dr. GLENNAN. Oh, yes.

Mr. SISK. For these captive stands and so on?

Dr. GLENNAN. That is right, sir.

Mr. SISK. That was the thing I wanted to make clear, because, after all, it would be a little bit foolish if on one hand we appropriate $40 million or $50 million or $80 million some odd in this case and then because of a few million dollars regarding a site here, we argued over that. It would seem to me it would be a little bit foolish. That is why I wanted to get a breakdown here as to just what we are talking about.

I might say, frankly, there was some concern on the part of the committee over this $40 million odd on Centaur.

On the other hand, there again we accepted it on faith, very frankly, because we have confidence in you people and the people that are working with you, that it is necessary in this overall space program.

Dr. GLENNAN. Thank you, Mr. Sisk.

Mr. Chairman, I would like to emphasize again that we have really a tough problem in trying to find the kind of a site which will avoid hazards to people and property, in dealing with these highly toxic materials.

This is one of the reasons that it takes a little longer to find this sort of thing than the ordinary site.

Rather than being rushed into this thing, it seems to me that perhaps we ought to be supported in our efforts to be as careful and reasonably safe in site selection as possible.

Mr. FULTON. Mr. Chairman.

Mr. BROOKS. Mr. Fulton.

Mr. FULTON. Might I say to the good doctor—and we are sympathetic—that because of the rules of Congress, there are certain things that can be done and certain that shouldn't.

I would recommend to you that you look over the record of this hearing and that as a friendly counsel, that you accept the advice of the majority leader on procedure. Those of us that have been here for some time know that it is excellent advice and it is careful under the circumstances.

I believe the gentleman from Massachusetts would agree with me, would you not?

Mr. MARTIN. Yes.

Mr. FULTON. Mr. Martin agrees on the same thing.

The other point is this: We are not rushing you any further than you should be rushed because we think you should go quickly on these programs.

Secondly, we have already adopted a commitee policy by a vote here, that unanimously took the position that we did not want the head of a specific program or site location to authorize money which

would then be passed over to the Appropriations Committee for action. That is against the general policy of this committee, regardless of this particular instance.

Now, under those circumstances, when it is exactly contrary to the committee policy that has already been established, for us to do otherwise, and secondly where the majority leader has given a very good procedural format for accomplishing what should result, I would suggest that under those circumstances if you will look this over and adopt the advice of the majority leader, that you are safe. And then the assurance that Mr. Miller has given and I am sure the chairman and I would give to you—that if you come back here at any time asking for an authorization and with a reasonable proposal for a site or if you have kept the committee advised, the particular subcommittee under the chairmanship of Mr. Miller, so that we know, we probably would accept their recommendation, so that you would have it within 5 minutes when you need the authorization.

That can be done later in this session of Congress at any time.

But again I would have to say to you my firm opposition to authorizing a plant or any equipment or fences or roads in an amount where I couldn't say that I could justify it.

Let me finish finally on the matter of the floor. To those of us who will have the burden of defending this proposed budgetary program on the floor, it will be a tremendous assistance to have been able to say that at the present time we have been careful. It is down for the present $4,750,000.

That assures you a very much warmer welcome for the rest of your program, because you should keep in mind that there may be an attack on this program as "simply shooting the moon and wasting the taxpayers' money and why do we have to go into space when we have enough trouble as it is here."

So that you are under that circumstance greatly increasing the power of the hand of this committee by permitting us to go through this legislative procedure.

May I finish with a compliment. As you remember last year I had opposed strongly putting the Venus probes in, because I feel that if we move those up in time we are setting other things aside.

I want to emphasize that I hope that on the cislunar space and everything in our strategic area we combine both science and strategy and go ahead strongly on those programs, in view of this postponement.

Thank you.

Dr. GLENNAN. Mr. Chairman, I am very grateful——

The CHAIRMAN. Mr. Hechler wanted to say something. Do you want to ask a question at that point?

Mr. FULTON. Ken, would you yield?

Mr. HECHLER. Yes.

The CHAIRMAN. Then I want to ask you some questions for the record that are helpful in this field, too. Go ahead.

Dr. GLENNAN. Mr. Chairman.

The CHAIRMAN. Doctor.

Dr. GLENNAN. I am grateful for the suggestions of the majority leader. I have very much to learn in this field of congressional rela-

tions and the manner in which these things are accomplished. And certainly we want to profit by the great experience that is so evident.

I do, however, point out that I think the road that we will follow in this matter is simply a road of a year's delay.

Now, in this I simply think the committee shares the responsibility with us. We need this facility. The fact that we have not had the time to select the site seems to me not to lessen the importance of the committee's endorsing our need of the facility and authorizing a sum of money, in this instance $4,750,000, for the development of this site at the highest possible urgency.

The CHAIRMAN. Mr. Hechler.

Mr. MCCORMACK. Mr. Chairman, I don't think you should suddenly try to transfer the responsibility to this committee, Doctor.

Dr. GLENNAN. I don't want to.

Mr. MCCORMACK. I am very friendly now. It is not the committee's fault.

Now, we are not blaming anybody. But you ought to come up here with a particular site.

Now, if we went on the floor of the House of Representatives with a bill authorizing the appropriation of $4,750,000 or any amount of money for construction of a site not selected, why they would laugh us out of the House of Representatives, and we would have to advise the House because we couldn't withhold that information. It would be intellectually dishonest on the part of the committee.

Mr. MARTIN. The rules of the committee might not permit you.

Mr. MCCORMACK. The House would laugh it out of the window. So we are trying—this is just a little family affair, trying to give you a little advice.

Dr. GLENNAN. I appreciate that, sir.

Mr. MCCORMACK. Nobody wants you not to hasten. On the other hand, it is your job to come up here with a particular site. Then the subcommittee or the full committees, whichever—I suppose it will be referred to a subcommittee. The subcommittee will cooperate with you. We have all expressed our willingness to cooperate. But to authorize the appropriation of money on something that is not in being—why to have us take the responsibility or share it. I suggest you reconsider that.

Mr. MILLER. Mr. Chairman——

Dr. GLENNAN. I simply defer to your judgment, sir.

Mr. MILLER. Mr. Chairman——

The CHAIRMAN. I promised to recognize Mr. Hechler.

Mr. HECHLER. I yield to the gentleman.

The CHAIRMAN. Yes.

Mr. MILLER. Mr. Chairman, I wanted to call your attention to section 3 of the bill:

> Any amount, not to exceed $5 million of the funds appropriated for construction and equipment,

and that represents $58 million,

> pursuant to this act, may be used to construct, expand, or modify laboratories and other installations, if found by the Administrator to be necessary because of changes in the national program of aeronautical and space activities or new scientific or engineering developments and if the Administrator determines that deferral until the next authorization act would be inconsistent with the interests of the Nation.

And we examined that in the committee. I believe this applies in this case. In the event you do select the site, you go to the Budget and get them to let you use that $5 million. Certainly you are not going to use all the $57 million before the end of the next fiscal year. Congress will be back here in January and could in its supplementary restore the $5 million that you would transfer from other sections of the budget.

If this section isn't applicable, I am going to ask the counsel to examine it and to furnish language to the committee that would make it applicable, so that we can write it in here.

But we are of the opinion at this time—and we took it up in the subcommittee—that this section is applicable. Is that not right, Mr. Counsel?

Mr. DUCANDER. Yes, sir.

In order to make it very clear we might have to change a few words in the section, but aside from that I am sure we can make the section applicable.

The CHAIRMAN. We will go into that in executive session.

Mr. MILLER. Yes.

The CHAIRMAN. Doctor, I would like to ask you one or two questions.

Now, on page 1, line 5, you refer to such sums as may be required for salaries and expenses for research and development.

Now, it would make better legislation if we could put in the amount which you require for salaries and expenses. Now, what is the amount that you are requiring for salaries and expenses?

Dr. GLENNAN. $94,430,000.

The CHAIRMAN. $94,430,000.

Dr. GLENNAN. That is right.

The CHAIRMAN. Now, also, what is the total amount required for research and development?

Dr. GLENNAN. $333,070,000.

The CHAIRMAN. Then one final thing. For construction and equipment, what is that amount?

Dr. GLENNAN. $57,800,000.

The CHAIRMAN. All right.

Mr. Hechler, do you have a question now?

Mr. HECHLER. I wanted to get back for just a moment to this central facility.

Dr. GLENNAN. Yes, sir.

Mr. HECHLER. I wondered if you could give us, with a little more precision, the criteria, that is, the difference between remote and isolated. I can understand thoroughly the need for locating this facility away from urban areas so that the noxious gases would not endanger human life. Yet I wonder if you could give the committee some more precise definition of remote and isolated?

Dr. DRYDEN. I can't give you the numbers, I am sorry. But you may recall that fluorine is a chemical which will etch glass.

It is, in very small concentrations, very damaging to the respiratory system. If you breathe air containing small amounts of fluorine, you will get a congestion and trouble.

It is in a small degree related to the atomic problem. In other words, you have to look out for what the effect of wind currents are,

if you should release a certain quantity. You do have hydrofluoric acids present in the exhaust gas from the rockets. So you must consider meteorological factors, for example, as well as just plain distance. So you don't get clouds of this blown over a house or a community without it being dispersed to an extremely low concentration.

I don't happen to know what permissible concentrations are, except that they are very low.

Mr. HECHLER. What I was looking for, of course, were some of the criteria that you had established and how definitely you had established these in your search for a site.

Dr. DRYDEN. They are in process of establishing these criteria now.

Mr. HECHLER. These have not been made available to the site committee, then, is that correct?

Dr. DRYDEN. Not as yet. The site committee will have some voice in establishing these criteria.

Mr. HECHLER. If I may be permitted just one more question, Mr. Chairman.

Do you have any general estimate about the time for the development of the criteria prior to the actual selection of site?

Dr. DRYDEN. The next couple of months, something of this sort.

Mr. HECHLER. This will take about half of the time of the site committee, then, approximately.

Dr. DRYDEN. It will take maybe a little less than that.

In estimating the time that it will take to select a site, I was considering one past experience and the interest in this site on the part of many areas of the country. It is our intention to look at any site that is seriously proposed, and this takes time, as you know, to send people around and to talk and see and collect information.

Mr. HECHLER. I merely want to say for the record that West Virginia has sometimes been referred to as a remote area.

The CHAIRMAN. An unemployment area, too.

Mr. MCCORMACK. Mr. Chairman.

The CHAIRMAN. Mr. McCormack.

Mr. MCCORMACK. Section 3, Doctor. As to this $5 million relaxation, I might call it. It says on line 24 "until the next authorization act." That is to give you some freedom of action between the adjournment of Congress this session and the beginning of the next session.

Dr. GLENNAN. Exactly, sir.

Mr. MCCORMACK. In other words, if the provisions of this section aren't exercised by your agency between now and when Congress meets in January, you are not going to exercise those provisions, is that correct? In other words, the next authorization act—you don't mean 2 or 3 years from now. Do you mean——

Dr. GLENNAN. Could I ask counsel to comment on that, please?

Mr. JOHNSON. Mr. McCormack, to be sure that I understand your question properly, would you repeat it to me, yes?

Mr. MCCORMACK. Yes. I think there ought to be understanding on the part of the committee just what your construction of that language is—"until the next authorization act."

As I understand it, this section 3 is to give a relaxation to the agency, to the administration, that is, up to, not exceeding, $5 million, in

changes that experience might show necessary, consistent with the interest of the Nation, and so forth. That language means—I want to find out if it means that it will be exercised between the adjournment of Congress and the meeting of the next Congress, that is the next session of this Congress?

Dr. GLENNAN. This authority, if granted, could be exercised, yes, between the adjournment of this Congress and the commencement of the next Congress, and for that matter even during the session of the next Congress prior to the enactment of the next authorization act by the next Congress.

This language I should say is copied almost precisely from language which is contained in current legislation for the military departments—the Department of the Air Force specifically, which I know you gentlemen are acquainted with.

It has been used for the purpose of emergency construction, modification and so forth, of facilities when such action could not await the enactment of the next authorization bill.

Mr. MCCORMACK. In other words, if there is not another authorization bill in the next session of Congress, it goes all through the next session.

Dr. GLENNAN. This is theoretically possible, yes, sir.

Mr. MCCORMACK. Practically possible, if there is not another authorization bill in the next session.

Dr. GLENNAN. It seems quite inconceivable I would think in practical terms that there would not be an authorization bill in the next session.

Mr. MCCORMACK. I probably agree——

Dr. GLENNAN. But the language, of course, does speak only in terms of the next authorization act. I think this is a theoretical possibility, but not a practical one.

The CHAIRMAN. We could write in not to extend beyond the next session of Congress.

Dr. GLENNAN. Certainly.

Mr. MCCORMACK. I wasn't asking the question for that purpose. I just wanted to get an idea.

Mr. Chairman, I wasn't asking the question to refer the language—to confine it to this session. I wanted to get the thinking of Dr. Glennan and his associates.

In other words, do you expect another authorization bill in the next session of Congress?

Dr. GLENNAN. Yes, sir. And the thinking certainly behind this bill is that it is only an annual type of authority granted to us, one to last until the Congress were to take action on the following regular half annual authorization act. That was the thinking behind the section, sir.

Mr. MCCORMACK. Well, if we—well, all right.

Dr. GLENNAN. Mr. McCormack, you understand that this only applies to the construction of facilities.

Mr. MCCORMACK. I understand.

Dr. GLENNAN. Construction and equipment. And actually I think the concern here is that, again, in the new game, changing as fast as this one we think will change, if we had to have, for instance, one additional pad, launching pad, it might take $3 to $4 million, and it

might be more important to us at that point in time and more important to the Nation, than going ahead with one of the other construction items which is listed here.

Mr. McCormack. I wasn't raising that question at all.

Dr. Glennan. I see.

Mr. McCormack. I just wanted to get the thinking of you and your associates as to how long this somewhat broad authority might continue.

Mr. Fulton. Mr. Chairman.

The Chairman. May I ask you one question, Doctor? When I was up in Boston the other day, in the home of my two colleagues here, one to the right and one to the left, some newspaperman asked me about future authorizations of NASA and he referred to the fact, I believe, that you had made some statements about the possibly needed authorizations in the future.

I think the sum of $1 billion next year was used, the next fiscal year, and perhaps higher than that. I think I disappointed them because I wouldn't go any $5 billion authorization for next year.

Dr. Glennan. Mr. Chairman, whoever was asking these comments to you was misquoting me. I think the record will show in the hearings before I believe this committee as well as the Senate Space Committee, that in an attempt to be perfectly fair and honest about what I can see as an on-going program here that might well want to be supported, that—I believe I said that I doubted that we would again bring before the committees a request for funds less than a half billion dollars. This is $485 million. And that within the space of 2 to 3 years it might well be that a program prosecuted vigorously would run to $1 billion a year. I think those were the words that I used.

The Chairman. Thank you, Doctor.

Mr. Fulton. Mr. Chairman.

The Chairman. Now, Mr. Fulton.

Mr. Fulton. The question comes up on the calendar of this particular installation that the gentleman from West Virginia is mighty interested in.

If it is going to take, say, 3 to 4 months for the selection committee to come up with a site, that brings us up into August of this year.

Dr. Glennan. That is right.

Mr. Fulton. Then I would judge that on this type of installation, on the plans and specifications, it would possibly take you at least 4 to 5 months thereafter, once you have chosen the site, to come up with the necessary plans and specifications of the ordinary buildings, production centers and facilities.

Mr. Hechler. Four to six months for the site, if the gentleman will yield, was the question.

Mr. Fulton. I have cut it down, on the basis if they can do it in 3 to 4 months. But they said 4 to 6 months.

Under these circumstances where there may be some research and development work, as to how to put these facilities, because after all they are experimental and they are new. Don't you think that even if we took the minimum of 4 months to select the site and put another 4 months on for the plans and specifications, that it would really be 8 months from today, and Congress would be back in session before

you even spent any appreciable amount of the $4,750,000 for constuction?

You see, you would not have laid out any money at all probably before January, February or March of next year, when we are in session.

So that to me it becomes all the more apparent after I have thought it over for awhile, that you should take the advice of the current majority leader, and I might say the advice of the former speaker.

Mr. SISK. Mr. Chairman.

The CHAIRMAN. I think—I will say this: No personal reference. But it is 11 o'clock and we have some official business. So I think we should soon go into executive session.

Mr. ANFUSO. Mr. Chairman.

The CHAIRMAN. Mr. Sisk.

Mr. SISK. I simply want to pursue just a little further, of course, the line of thought I started awhile ago and also that the gentleman from Pennsylvania brought up. Now, we in our subcommittee recommended to this full committee $8 million for R. & D. in solid propellant rockets and high energy propellant rockets. Now, how much of this $8 million is going to be required at this site?

Dr. DRYDEN. This site could not be completed in time to use those funds, Mr. Sisk. They are in current facilities.

Mr. SISK. That $8 million for high energy propellants and so on are going to be used on some other facility?

Dr. DRYDEN. On the smaller scale that I spoke about before.

Mr. SISK. Thank you, Mr. Chairman.

The CHAIRMAN. Mr. Anfuso.

Mr. ANFUSO. Mr. Chairman, the question of whether or not we are going to have higher or lower appropriations leads me to ask this question. It will only take a yes or no answer.

And I would like to ask this question since we have the high brass here of NASA—Dr. Dryden, Dr. Glennan, and Mr. Johnson.

You all know of this magazine, "True Magazine," I believe. And this magazine, Dr. Dryden, disputed your statement about Lunik.

Dr. DRYDEN. Yes.

Mr. ANFUSO. This magazine could do an awful lot of damage. As a matter of fact, I was invited to attend a newspaper conference in New York where the author was going to make a speech. I understand he has been invited to make a speech here in Washington.

Now, if the article is untrue, then I think we ought to call it untrue as quickly as possible and make the American people feel that there is nothing to it. Then they would become lackadaisical again and we wouldn't get the cooperation that we want to get and the cooperation that you want to get in building up this program.

Therefore, I have consulted our chairman, and I would like to ask you this question: Would you welcome a private probe of this situation, in executive session? Would you be able to bring down the proof——

Dr. DRYDEN. Yes.

Mr. ANFUSO. That you think is necessary and let them come in with any proof that they have to the contrary, and in an executive session thrash this thing out?

The CHAIRMAN. I will say this to the gentleman, that we have 2 days of hearings set up on that subject already.

Mr. ANFUSO. Oh.

The CHAIRMAN. Before the full committee and we are calling the witnesses.

I feel that that is something that ought to be in open session.

Dr. DRYDEN. Yes.

The CHAIRMAN. I feel very strongly that way, too. I don't think it should be withheld from the press.

Mr. ANFUSO. It should be investigated.

The CHAIRMAN. Correct.

Mr. ANFUSO. I am glad to hear that the chairman is going to go into that.

Mr. KING. Will the author of that article be present?

The CHAIRMAN. If we can get him.

Mr. Ducander, will you make note to try to get the author of the article?

Mr. DUCANDER. Yes, sir.

Mr. MILLER. The gentleman yielded to me. I would like to make this observation. I think we are giving True Magazine a great deal of free publicity, and we are playing right into their hands. I think that True Magazine has been known—everyone knows what it is. We lower ourselves to even take cognizance of their story.

Mr. ANFUSO. That is why I suggested an executive session.

The CHAIRMAN. Any further comments?

(No response.)

The CHAIRMAN. If not—it is now 11 o'clock. We want to thank Dr. Glennan and Dr. Dryden and all of you gentlemen for coming here and being present and giving us your testimony.

The committee will now go into executive session.

(Whereupon, at 11 p.m., the committee proceeded in executive session.)

1960 NASA AUTHORIZATION

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS
SUBCOMMITTEE ON TRAINING AND FACILITIES
(SUBCOMMITTEE No. 1),
Washington, D.C., Friday, April 24, 1959.

The subcommittee met, pursuant to notice at 2 p.m. in room 313–A, New House Office Building, Hon. George P. Miller, presiding.

Mr. MILLER. The committee will be in order.

Mr. DUCANDER. Mr. Chairman, the meeting of the subcommittee this afternoon is to consider the provisions for construction facilities and equipment in H.R. 6512. We have Mr. Ira Abbott, Mr. Edmund Buckley, Mr. John Townsend, Col. Don Heaton, Mr. Bob Nunn, and Mr. James Gleason here from NASA, who will assist the subcommittee on any questions they may have concerning these projects.

Mr. MILLER. I think we start on page 322 of the green book, is that right?

Mr. DUCANDER. Yes, sir.

Mr. MILLER. Mr. Abott, are you going to lead off?

Mr. ABBOTT. Just as you wish, Mr. Chairman.

Mr. MILLER. All right, sir.

Mr. ABBOTT. The first item is for the construction items for the Langley Research Center at Hampton, Va., totaling $4,580,000 under which the first item is "Alterations to the terminal structures tunnel" in the amount of $745,000.

Would you care to discuss these items one by one, Mr. Chairman? Or how do you wish to proceed?

Mr. MILLER. Have you had a chance to look at this?

Mr. OSMERS No, I have not.

Mr. MILLER. I have not had a chance to go through it. I have read the first two or three justifications but how far do we go in this?

Mr. DUCANDER. Mr. Chairman, we go through quite a number of pages. In the bill we have——

Mr. MILLER. In other words, I was going to say, if you could summarize in a few words each item, then if we have any questions we can ask them.

Before you get into this, though, I noticed in here you are asking for an analog computer and digital computer. I think I know what a digital computer is. It is a glorified adding machine. In other words, it deals with natural numbers. The analog computer, I assume, brings in the powers of numbers, something like logarithms, is that right?

Mr. ABBOTT. Mr. Chairman, an analog computer does not deal with numbers. It substitutes for the numbers some physical property. A good example is a slide rule with which I think you are familiar.

Mr. MILLER. Well, I was going to say this: I think, if you could furnish for Mr. Ducander the definition of those two—because I do not know that we have ever had them challenged on the floor but I can conceive of one man who might want to know what is the difference between a digital computer and an analog computer, and unless we know what it is, it is going to be embarrassing to us.

He can go off on a tangent and make a very good speech about it. I do not have to draw any pictures, do I?

Mr. OSMERS. Mr. Chairman, a point of information: Are you referring, when you use the word "digital computer" to the analytical computing equipment on page 322?

Mr. MILLER. Yes, I was. While I had this in mind, I had failed to make a note of it. But when I went over it this struck me, so, if you will do this, I will appreciate it.

(The information is as follows:)

DEFINITIONS

Digital computer

A digital computer is a device for the precise addition, subtraction, multiplication, and division of numbers. It ranges from the small familiar office adding machine to complex electronic devices that require whole rooms for their installation. The electronic digital computer, however, is what is usually meant when the term "digital computer" is used.

The electronic digital computer can add, subtract, multiply, and divide extremely fast. Their operation is so fast and accurate that the computing instructions are stored in the machine ahead of time along with any other reference information that may be required. Large quantities of experimental test data can be rapidly processed. In additions, solutions of complex equations can be obtained in a matter of seconds or minutes which would take days or even years if attempted manually.

The art of designing electronic digital computers as well as their complexity is rapidly expanding. They can catch their own mistakes, as well as tell what part is out of order, if a component should break down. In fact, such machines are being used to design new and more useful and complex computers.

Digital computers may or may not work on problems involving real time. In such a problem the answer is required as the event takes place. An example is the determination of the flight path of the X–15 airplane based on radar measurements taken during flight. Such information would come out of a digital computer in the form of numbers that can be converted to positions.

Analog computer

In contrast to digital computers which performs arithmetical operations on numbers, analog computers solve problems by substituting another more easily understood system for the actual events or problems being studied. They provide quantitative answers in easily measured physical form such as lengths, rotation of shafts, voltages or currents. The most common analog computer is the slide rule which substitutes graduated lengths for numbers. More complicated mechanical analog computers commonly use shaft rotations to solve arithmetical problems.

Large, modern, analog computers are usually electronic and substitute complex electronic circuits for the physical system being studied. The answers from such machines are commonly produced in the form of voltages or currents which are easily measured.

The airplane flight simulator is a particular type of analog computer. The aerodynamics and other characteristics of the airplane, including any automatic control devices, may be set into the complex computer circuits. The cockpit may contain all the flights instruments and controls but never leaves the ground. All of the events of flight may be simulated. The pilot moves the controls in the simulator and the instruments and sometimes the motion of the cockpit, tell him what the actual airplane would do under the same circumstances. All of the pilots who will fly the X–15 research airplane will have spent much time on several X–15 flight simulators prior to flights in the actual airplane.

Mr. OSMERS. Mr. Chairman, I think your method of proceeding is excellent. I would just like to ask one general question before we start on any item. I wondered if Mr. Abbott would tell us a little bit about the decision-making process within NASA before reaching the recommendations which you have here, and also how this work will be done. Will it be handled by the agency or through GSA, or how will it be accomplished, assuming that the appropriations are granted?

Mr. ABBOTT. Yes, sir. The proposals for construction at such places as the research centers, which are long established, typically come to NASA headquarters as proposals from the centers themselves following their analysis of their needs, in consultation with headquarters with regard to the direction of the program and the needs of the whole organization.

This consultation takes place continuously throughout the year.

Then when the budget-making procedure starts, the research centers submit to headquarters what they consider to be their facility needs for the next budget with justifications for them.

These are then considered by the appropriate officials in the headquarters staff at the levels lower than the Administrator, first, and are discussed with the field people who have proposed them. This usually results in some changes in these submissions.

Similarly, on the other facilities where the field centers are not yet so well established—for instance the space project center at Beltsville, the Pacific Missile Range, and various locations—the activity of the headquarters staff is more pronounced in the early stages of preparation than in the case of the research centers.

These needs are first defined by consultation between the people in the field, where they exist, and the headquarters people associated with those programs.

After these programs are well analyzed and coordinated within the Office of the Director of Aeronautical and Space Research, who handles the research centers and the Office of Space Flight, who handles the other work, they are then brought together and discussed with the Administrator and Deputy Administrator to combine them into a complete program.

Of course, the Office of the Director of Business Management has been active throughout this whole process.

Mr. OSMERS. Do they place the dollar valuation—that is, your budget division—do they put the price tag on the approved alteration or construction or acquisition?

Mr. ABBOTT. Let me say that they have an important part to play in this. Again reverting to the research centers, the research centers themselves, being long established, have important business management and construction groups within themselves who are very capable for preparing cost estimates, working together with the technical people. Headquarters usually finds it unnecessary to change their estimates because of this.

In the case of the facilities for stations which are not yet so well established, these cost estimates are worked out cooperatively between the technical people who know what they want, the construction people who know what can be built, for how much money, and the

business management people. An estimate is finally made with all these people taking part in it.

Mr. OSMERS. Then the other part of the question—which will conclude my question—you have now told us, Mr. Abbott, how the amounts get here and get before us at this time. Now, assuming that the appropriations are eventually made, does NASA itself directly contract for this work, construction, purchase of equipment, and so on?

Mr. ABBOTT. In practically all cases NASA does this itself instead of operating through another Government agency, making liberal use of engineering contracts for architectural services and that sort of thing.

And, finally, in practically all cases on major construction items, letting the contract on the basis of the bids.

Mr. OSMERS. Normal competitive bids.

Mr. ABBOTT. Except in those cases where the equipment involved is research equipment of such an unusual nature that the competitive bidding procedure is not appropriate.

Mr. OSMERS. How does NASA protect the Government from excessive costs in those area which might be quite considerable where only one concern would make the equipment? Say analytical computing equipment, here, $2,645,000. I do not suppose there are more than a few firms that make this equipment.

Mr. ABBOTT. I think that nearly always there are more than one, as you suggest, sir, at least a minimum of two or three in practically all fields. In such cases these competative negotiations are conducted in a rather hard-boiled manner by our staff people, both technical people who are very familiar with the technical requirements of the things that we wish to buy, and our business management people who are competent, I believe, in the business field.

The protection of the Government, I think in the last analysis, rests with the skills and industry of these people in properly conducting these negotiations.

In cases where we have run into what we considered excessive costs, we have usually tried to find some other way of getting the required results without completing those negotiations. In other words, we have tried to find other ways to accomplish the overall result without trying to get the equipment we originally thought we had to have.

Mr. OSMERS. The problem I anticipate, Mr. Chairman, is this: When this Committee on Science and Astronautics presents these figures, or whatever figures we do present finally, I think we will probably be in for sharp questioning as to how the interests of the Government are protected against collusion and against monopoly type of bidding on some of these items that may not even exist today and will have to be built especially for this purpose—for instance, a zero power reactor, $605,000. I do not suppose that an item like that lends itself to competitive bidding as 100 pairs of trousers would, or something else.

Mr. ABBOTT. Our people, both in the technical field and in the business management field, have a great deal of ability in costing a project. I think this is a very valuable thing in getting our money's worth out of these purchases.

I think it would be well for me to mention the reputation that the old NACA had in this field, generally, I believe, throughout the Government and throughout industry for getting its money's worth.

In fact, I think the reputation, in general, was that we were not satisfied unless we got a lot more than our money's worth.

Mr. MILLER. The business management people of NASA are substantially the business management people of NACA in that field, I presume.

Mr. ABBOTT. Yes.

Mr. MILLER. You have not added to it. Where you have added to the staff of NASA, it has been more in the scientific than the administrative field. Isn't that correct?

Mr. ABBOTT. Yes, sir. This is mostly true. We have retained the entire business management staff of the NACA, and have strengthened it by bringing in people of outstanding reputation to add to it.

Mr. MILLER. I think your position is well taken because we are going to be called upon and they will be more critical of this than they would be of the Armed Services Committee that for years have dealt through the Corps of Engineers or the Bureau of Yards and Docks, or well recognized governmental agencies that are known to the Congress.

I see here, this analytical computer, the power reactor, the ion and jet facilities, then on the other page, the analog computing system, and so forth: Whereas, none of these things are completely new in Government, other agencies have analog computers, or other agencies have power reactors so that your business people do have guidelines or experience to go on talking about these things when they go to negotiate the contracts.

Mr. ABBOTT. Yes, particularly on the types of items you have mentioned. On some of the other equipment, more particularly the hot wind tunnels and such apparatus, the major experience not only in the United States but at least in the Western World, has resided in the NACA which did conduct rather large construction programs of this sort.

I might point out, for instance, our part in the unitary wind tunnel program in which the single year's appropriation exceeded the total amount requested here by a substantial margin, about 50 percent. This program was constructed and carried out in such a manner that we got more wind tunnel per dollar—and I believe this is universally agreed both in other Government agencies and in industry—than anybody else has ever succeeded in getting before.

Mr. MILLER. I suggested, Mr. Chenoweth, we have the books and there is a backup justification for them.

We have asked Mr. Abbott to rather summarize them than to try to read and go into all of the backup justification for each item. We would be here for a long time.

Then, if there is anything, any particular item you might want to know about, we can ask about it. So, if you will proceed, then, to tell us as briefly as you can what these items represent.

Mr. ABBOTT. Yes, sir.

The first item at Langley, alterations to the thermal structures tunnel, has to do with some alterations and modifications to a facility which has been operating now for approximately 2 years. This wind tunnel is constructed to provide tests under realistic conditions of airspeed and temperature up to speeds of approximately 2,000 miles an hour.

The structures of missiles and of airplanes are seriously affected by thermal stresses and the high temperatures set up under flight conditions. This wind tunnel permits us to make realistic tests of large-size specimens of actual construction.

The alterations which are wanted here are to reduce the loads applied to the model during starting and stopping conditions in order to permit us to test models which are more nearly representative of the actual construction that will be necessary on the wings and fins of such vehicles.

Mr. MILLER. I am not going to ask each time if there are any questions. You can raise the questions. Go ahead.

Mr. ABBOTT. Thank you, sir.

The analytical computing equipment at Langley was the subject of a rather lengthy discussion by myself before the full committee and has to do with the need for a central computing system for use with simulation equipment, which would be located at various locations throughout the Langley Laboratory.

Much of this simulation equipment involves putting the pilot, for instance, in cockpits which duplicate on the ground many of his motions, but of course not all of them, in the air, and also for simulating actual components for automatic control and stablization equipment. This requires that these pieces of simulation equipment be located in various laboratory buildings.

Our intention is to tie these locations by telephone lines into a central computing system so we would have great flexibility in conducting this simulation work which is of great value in analyzing the pilot problems of manned vehicles and the automatic control and guidance problems of unmanned vehicles.

The next item is conversion of the gust tunnel into a noise research laboratory. That is an example of our making use of an obsolete facility for an entirely new purpose. We did have a gust tunnel at Langley which was used to study the effects of gusts on airplanes. This research has been substantially completed and this gust tunnel is now no longer in use. It is singularly well adapted to being modified into a facility for conducting fundamental research on noise which, as you know, is a very serious problem to both military airplanes and civilian transport airplanes.

Mr. MILLER. I wish you could find something that would do something with the sound barrier because out in our part of the country right now the papers are full of stories of people who have been breaking the sound barrier and a few windows.

Mr. ABBOTT. We only hope to be able to do something about this, sir.

Mr. MILLER. General LeMay told them very frankly they had to learn to live with it from now on out. He did not pull any punches.

Mr. OSMERS. Mr. Chairman, coming, like you have, from a densely populated part of the country, we have not had in the New York metropolitan area too much breaking of the sound barrier, but we do have a very serious aircraft noise problem.

I would just like to ask whether, in that noise research laboratory, you devote yourself to piston-type engines and jet engines, or whether that is the whole gamut, or to certain specialized equipment that would deal particularly with the program of NASA?

Mr. ABBOTT. Sir, we will be dealing primarily with such noise sources as jets of various types, whether from turbojet engines or from rockets. But we will, of course be interested in the other noise sources that are on various types of aeronautical and space vehicles when they are in the atmosphere.

Mr. OSMERS. May I ask, Mr. Chairman, this question: Aside from what I happen to know some private companies are doing in noise suppression work, are there any Government agencies that are presently engaged in noise research in connection with aircraft or not?

Mr. ABBOTT. Yes, sir, we have been very actively engaged in this work some years now. Much of the work on these noise suppressors has been done, the research work on them, at our Lewis Research Center. I think we have fairly well outlined the possibilities of such noise suppressors as applied to the current types of turbojet engines. They do provide a considerable benefit, but not as much as we would like, of course.

The purpose of this facility is to do more fundamental research on noise sources of all sorts and on noise propagation problems, which is also very important from the annoyance point of view.

The next facility, conversion of a test cell to a noise test facility is another example of converting an obsolete facility to a new purpose. This is a very heavy concrete test cell originally intended for testing of engines.

The heavy concrete construction of this cell makes it a good place to test very loud noises. These very loud noises have drastic effects on the structure of the vehicles. We expect in this cell to be able to reach noise levels on the order of 170 decibels noise levels which correspond to those close to a rocket exhaust for instance. The noise itself causes metal structures to fail, sometimes in a matter of only a few seconds, and this is presenting a great deal of difficulty.

This second noise facility is not for fundamental research on noise, but for the study of the effects on the structures of these very loud noises and for structural research to find out what can be done to counteract these effects.

Mr. MILLER. Joshua could have blown down the walls of Jericho if he had enough decibels.

Mr. ABBOTT. Yes, if he had enough decibels, the walls would fall down.

Mr. OSMERS. You do not think, Mr. Chairman, we need have any fear for the Senate side of the Capitol, do you?

Mr. MILLER. No.

Mr. ABBOTT. It is easy to understand why we want to make such noise inside a test cell with very thick concrete walls.

The last item, the heater and vacuum system for the gas dynamics laboratory, $585,000, is another matter of modernization of a facility which has been in operation for some years. We have in this gas dynamics laboratory some 20-inch wind tunnels now capable of reaching speeds corresponding to about 8 or 8½ times the speed of sound. We are marginal with regard to the capability for heating the air required to operate these wind tunnels to prevent the air from condensing as it goes through the wind tunnels.

We also are seriously in need of facilities for doing flutter work at these very high mach numbers. This cannot now be done in this

laboratory, or in any other place, because of the very severe loading conditions applied to the models in starting these very high speed wind tunnels.

The modification which is requested here would permit us to do flutter work in these jets by reducing the pressure in the jet to a very low value while the jet is starting, and while the severe shock which causes heavy loading in the model passes over it. Then with the jet running we could increase the pressure to duplicate the loads on the model under the environmental conditions.

Mr. MILLER. That finishes Langley. We will follow the system that we follow on the Armed Services Committee and approve these by item.

Unless there is objection, we will approve this and approve the thing in whole. I know Mr. Osmers is familiar with it.

Is there any objection, then, to the $4,580,000 for Langley? If not, we will consider that as approved.

Mr. CHENOWETH. Before you leave that, Mr. Chairman, I wish to inquire just what our operations are at Langley. Is this the amount you propose to spend this coming fiscal year? What would you say we have invested in Langley now in different facilities?

Mr. ABBOTT. The investment at Langley now is approximately $150 million.

Mr. CHENOWETH. Is that the largest of all of your stations of this type?

Mr. ABBOTT. Yes, sir, this is the largest.

Mr. CHENOWETH. That is your main one?

Mr. ABBOTT. Yes, sir, I think that is a fair statement, but our Lewis Research Center is almost as large.

Mr. CHENOWETH. Which?

Mr. ABBOTT. The Lewis Research Center at Cleveland is almost as large. The Ames Research Center at Moffatt Field, Calif. is still a large center as far as investment is concerned, the investment there being approximately $100 million but is only about half the size of Langley as far as employees are concerned.

Mr. MILLER. I think, for the Judge's information, in the old days Langley was the place where you did aerodynamics, was it not?

Mr. ABBOTT. Langley was the original research center of NACA.

Mr. MILLER. They had a separate function.

That is, there was overlapping, but a separate——

Mr. ABBOTT. Yes, sir. The Langley Research Center covers the widest range of problems. Langley does work on all phases of aerodynamics and in hydrodynamics. It is the only place in our organization where any work is done on hydrodynamics.

It also does work on structures and on operating problems of aircraft.

Our Ames Research Center is primarily aerodynamic and has specialized more on high speed aerodynamics.

Mr. MILLER. Big wind tunnels.

Mr. ABBOTT. Big wind tunnels at very high speed, hence a larger capital investment at Ames per employee.

It also does some associated work in such things as automatic stabilization and control and on structural load problems rather than on structures, themselves.

The Lewis Research Center is concerned with problems of propulsion and more recently also on powerplants for space vehicles.

Mr. MILLER. In other words it was the engine place?

Mr. ABBOTT. It was the engine laboratory.

Mr. MILLER. One was for the aerodynamics and the other was for materials.

Mr. CHENOWETH. These facilities weren't started then in connection with the missile and space program?

Mr. MILLER. No.

Mr. CHENOWETH. These are old facilities that have been used for years.

Mr. ABBOTT. The Langley Research Center was started in 1920. The Ames Research Center in 1939, I believe it was. The Lewis Research Center in 1942.

Mr. CHENOWETH. I remember visiting Langley at least 10 years ago on some of these demonstrations.

Mr. ABBOTT. We hope you will have a chance to come back.

Mr. CHENOWETH. I would like to see it. There is no duplication now in these different operations at Langley and Ames and Lewis?

Mr. ABBOTT. No, sir, no undesirable duplication. They do work to a certain extent in the same fields, but this work is closely coordinated, and there is nothing that I would call duplication, no, sir.

Mr. MILLER. The only work they do in the same field is the necessary application where it is necessary to integrate one part of the work in order to do the work in a specialized field.

Mr. ABBOTT. Yes, sir, that is correct.

Mr. MILLER. But there is no duplication. If you want to test out a wing or something of that nature, it is done out at Ames. When you want to put the wing and engine together, it may be done some place else.

Mr. ABBOTT. The work of the centers are closely coordinated so that each one does that which it is best suited for.

Mr. DUCANDER. Mr. Chairman, I wonder if Mr. Abbott could tell us what the Congress approved for Langley in the 1959 budget?

Mr. ABBOTT. Yes, sir, I have it here. The appropriations at Langley in 1959 for construction and equipment was $11,350,000.

Mr. GLEASON. Page 301.

Mr. DUCANDER. Page 301?

Mr. ABBOTT. Yes.

Mr. DUCANDER. Did it include, Mr. Abbott, any similar items that the committee has before it in the 1960 budget?

Mr. ABBOTT. No, sir, it did not.

Mr. DUCANDER. Anything in the 1959 supplemental for Langley?

Mr. ABBOTT. No, sir.

Mr. MILLER. All right, we will go on to Ames, then.

Mr. ABBOTT. The first item at the Ames Research Center is the data reduction center, which I described to the full committee. This is essentially a building to house the computing equipment at the Ames Research Center, which is now scattered in various locations throughout the laboratory creating very undesirable working conditions and making it impossible for us to improve the data reduction and analytical computing equipment of the laboratory to meet our current needs which are rapidly increasing.

So we are requesting this item of $2,505,000, to provide adequate housing for this equipment, and also to provide some computing equipment which we cannot get on rental—the amount of that being $660,000.

The mass transfer cooling and aerodynamics facility at the Ames Research Center is a facility to provide very high speed and very high temperature flows in the laboratory to permit us to study aerodynamic and heat transfer problems on the ground under conditions which we have previously been unable to duplicate.

This facility will provide three jets with air heated by electric arcs and will permit us to make tests under heating and speed conditions corresponding to flight conditions at approximately 12,000 miles an hour. It also will permit us to make aerodynamic investigations at higher speeds and to conduct heat transfer investigations under the very high heat transfer conditions that are encountered by ballistic missile warheads reentering the atmosphere.

Mr. DUCANDER. What is a Reynolds number, Mr. Abbott?

Mr. ABBOTT. A Reynolds number is a rather elusive parameter to explain which measures the scale of an experimental test in the field of aerodynamics. The higher the density and the larger the size of the model, the larger the Reynolds number.

The importance of Reynolds number arises from the fact that if the scale is too small, the results of the experiment will depart from those for the full scale article. That is, there will be a discrepancy in some cases between small scale tests and the rather large article which finally will be flying in the atmosphere.

So the Reynolds number is just a convenient measure of the scale of the test.

Mr. DUCANDER. Why do you call it a Reynolds number?

Mr. ABBOTT. It is called Reynolds number in commemoration of the great British scientist of the last century, Osborn Reynolds, who first pointed out the importance of this parameter and the fact that you did not get exactly the same results on a small scale test that you do on a large scale test.

Mr. DUCANDER. I see.

Mr. ABBOTT. This is one of the most difficult terms to describe that I have ever encountered, and I have been unable to arrive at any adequate description other than a mathematical one, which frequently is not very satisfying.

Mr. MILLER. It is a sort of a factor, then, by which——

Mr. ABBOTT. It is a measure of the scale of a test. A large scale test would have a high Reynolds number, a small scale test would have a low Reynolds number.

Mr. DUCANDER. Perhaps it would be better if we left that out of the report, Mr. Chairman.

Mr. MILLER. If there is no objection, we will consider Ames as approved.

Mr. DUCANDER. Mr. Chairman, before we pass on, and for the benefit of the record, may we have the figures for the 1959 and any supplemental that may have been——

Mr. ABBOTT. In 1959, the construction at the Ames Research Center was $3,720,000. There was no supplemental.

Mr. MILLER. Then we will consider Ames approved. The Lewis Center.

Mr. ABBOTT. The first item, the ion and plasma jet facility, is another one I described in some detail before the main committee. The purpose of this facility is to enable us to duplicate on the ground the vacuum environment of space in order to conduct research on the large sized electrical rockets that will be needed for the propulsion of space vehicles. The facility consists essentially of a very large vacuum tank and associated apparatus.

The zero power reactor, at $605,000, is an addition to the reactor at the Plum Brook Reactor Facility, which is an outlying station of the Lewis Research Center, and is located near Sandusky, Ohio.

The purpose of the zero power reactor is to provide a reactor having the same characteristics as the power reactor, but which will not produce power. It will just go to the point of producing power and no further. By the use of such a reactor, it is possible for us to put into this zero power reactor experiments which we will later put into the powered reactor, and carry them up to the point of criticality in order to check our calculations as to the effect of the experiment on the reactor, itself.

Mr. DUCANDER. I don't mean to be facetious by asking why do you call these things by their names, but so often we are asked down in the committee, why do you call it a zero power reactor.

Mr. ABBOTT. It does not produce any power. So the total amount of power the reactor puts out is zero. It never produces power. It only comes up to the point of being critical and no further.

This zero power reactor, in addition to permitting us more freedom in running experiments than we would otherwise have in the main reactor, also is an additional safety factor in the operation of the power reactor. It gives us additional assurance as to what we will be doing.

The in-pile loop is an experiment for the reactor facility at Plum Brook. The only reason this appears in the construction and equipment program is because its estimated cost is $250,000, which is the limit of our authorization for constructing individual items without getting specific authority.

These experiments for the reactor are very expensive, and in this case the facilities for the single experiment does come to this sum of a quarter of a million dollars.

This experiment will contain within itself the pumping facilities that will be required to duplicate experimentally an entire power loop that would be used for nuclear propulsion, plus a fuel element which will then be inserted in to the reactor, itself.

The item on land acquisition at $5,000 at the Lewis Research Center is an item which is a little complicated to explain. I think if you would turn to the map on page 362, it would help me a great deal in explaining this item. You will see on that map certain areas in the lower righthand part which are labeled areas A to F, respectively.

In 1958 we obtained authorization to procure land in this general area. It was intended at that time to procure the land which is described here as areas C, D, and F. Between the time we requested this authorization and the time that we got the money, area F became developed so that it was partially built up in homes with streets and

utilities, with the result that it became uneconomical to try to procure that area.

We then obtained areas C, D, and E under this 1958 authorization.

Now, area A, which is in the middle of this tract, is leased to the CAA who uses it in connection with the Cleveland Airport. This lease is renewable and has a clause in it permitting the CAA to buy the land. This present lease expires at the end of this fiscal year. The CAA intends to renew the lease but does not intend to exercise their option to buy the land. If this land were not used for governmental purposes, it would impose problems in the future because it is wholly surrounded by our land.

So we propose to exercise the option of the CAA lease to buy this land for the Government. It will continue to be occupied by the CAA so long as they have need for it.

Area B, which is part of the park area there, can be procured from the Cleveland Metropolitan Park Board, who have offered it to us, primarily because from their point of view it is now of camparatively little utility to them, seeing that we have already taken area E. It is of great utility to us to complete this land area and make a more compact land area, Also, the deep gully which runs down through area B is exactly the type of terrain that we need for some of our work on rockets and which would otherwise be almost impossible to obtain in that area.

So this is mutually advantageous.

Mr. CHENOWETH. Which part of Cleveland is this located in?

Mr. ABBOTT. This is right at the airport. The airport is adjoining.

Mr. CHENOWETH. That is some distance out of Cleveland, then?

Mr. GLEASON. The southwest part.

Mr. CHENOWETH. 15 miles out, isn't it?

Mr. ABBOTT. Yes, right on the edge——

Mr. CHENOWETH. Right by the airport.

Mr. ABBOTT. Yes. On the other side is the Rocky River Park. This area E was also park land which followed up the valley of a little stream which flows into Rocky River.

Mr. DUCANDER. How much per acre will you have to pay, Mr. Abbott?

Mr. MILLER. About $200.

Mr. ABBOTT. Twenty-five acres—yes, $200.

Mr. MILLER. Is that a reasonable price for land of that nature?

Mr. ABBOTT. Yes. We have had independent appraisals on this land which concur in this price.

Mr. MILLER. Certainly if area F is now occupied by homes, it must be pretty desirable property for that, and $200 is not an excessive cost per acre.

Mr. ABBOTT. Yes. This property shown in areas A, D, and C is desirable property to be built up into homes. The surrounding area is getting built up into homes. Area E and area B are different, inasmuch as they contain the gully.

However, you will notice on page 363 that the price per acre is different in the two cases. In area A, $2,500 for 8.6 acres, and in the case of area B, which has the gully in it, 16.4 acres for $2,500.

Mr. MILLER. You want that figure for 1959?

Mr. DUCANDER. Yes, sir, if you please.

Mr. ABBOTT. Lewis Research Center in 1959 had $7,800,000 for construction and equipment. No supplemental.

Mr. MILLER. If there is no objection, we will declare Lewis approved.

Now, High-Speed Flight Station at Edwards AFB, Calif.

Mr. ABBOTT. We have three items here, the first one being an item for a building addition in the amount of $955,000. Our increasing activity at the High-Speed Flight Station, and particularly the onset of such activities as flight tests of the X–15 airplane, which is a very extensive activity, has resulted in a situation where we do not have sufficient office space, shop space, or space for instrument calibration and preparation in our facility at that station.

So we are asking for an addition in this amount: This addition will consist of one one-story wing, and two small second-story additions to our present building at the high-speed station.

The analog computing equipment at $350,000 for the High-Speed Flight Station again is a matter of procuring adequate computing equipment to provide the simulation work that is needed in connection with the flights of these high-speed airplanes. These high-speed airplanes provide unusual piloting problems, as you can imagine, and the number and extent of these flights can be reduced considerably, and their safety can be improved, by extensive simulation work in the laboratory in which the pilot, by the use of this equipment, essentially flies the airplane without leaving the ground.

We need additional equipment of this sort very badly, as all the equipment that we now have at the station will hardly prove adequate even for the pilot training that will be required in connection with the X–15 flights.

The other item for $1,500,000 is for a terminal guidance facility which is very badly needed, especially in connection with the X–15 flights. We wish we had had this equipment before but it is only recently that the radar equipment and the possibility of modifying the radar equipment adequately has become available to permit us to get this equipment. These airplanes which have no power at the time they land, provide a very severe piloting problem in order to bring them down safely and land them on even such an extensive area as Rogers Dry Lake. The purpose of this terminal guidance facility would be to provide radar equipment on the ground, plus the computing and analyzing equipment that is needed to provide ground guidance to the pilot from a considerable distance out to practically the moment of contact with the dry lake so he would know where he was, whether he was too high or too low, whether he was on the right course and whether his speed was right at all times.

This equipment will become available in time to be of assistance long before the X–15 program is completed.

Mr. MILLER. All of this takes place, his coming in without power, all has to take place within matters of almost split seconds, doesn't it?

Mr. ABBOTT. Yes, sir.

Mr. MILLER. He hasn't got time to call back and say what did you say and ask how the weather is down there.

Mr. ABBOTT. No, sir, he has no time to make mistakes or to engage in lengthy conversation. I forget the exact figures, but on the X–15, for instance, he might cross the field at an altitude of about 20,000

feet and be landing on the lake something like 2 or 3 minutes later, all with no power, so he has no margin to make a serious mistake.

Mr. MILLER. You can't wave him off.

Mr. ABBOTT. He cannot be waved off. He has to come in the first time. We know we can do this. We know we can do it without this terminal guidance facility because this has been the subject of extensive investigations on other airplanes which have been modified to duplicate the conditions that would be encountered by the pilot of the X–15. We also know that we would like to be able to do it more safely.

This is why we are requesting this equipment.

Mr. MILLER. There is no 1959 budget apparently.

Mr. ABBOTT. No, sir. In 1959 there was no construction money for the high speed flight station.

Mr. MILLER. Without objection, we will approve that item.

The space project center at Beltsville, Md.

Mr. ABBOTT. I would like to have Mr. Townsend speak to this.

Mr. MILLER. This is the new one, I believe.

Mr. TOWNSEND. This is the new one, sir.

Mr. MILLER. So we have no previous history of this one either.

Mr. TOWNSEND. No, sir, that is not correct. We had approved last year, the fiscal year 1959, $3,937,000 for the first two buildings of the Beltsville Space Center.

Mr. DUCANDER. As a matter of fact, you have just let the contract, have you not?

Mr. TOWNSEND. Yes, sir, within the last 2 or 3 weeks. If you will turn to page 376, it will perhaps be easier to go through this with pictures. The location plan is shown on page 376. The site is on land that was part of the Agricultural Research Center at Beltsville. This has been transferred to NASA. The actual location is very close to the intersection of the Parkway and Glendale Road. The Glendale Sanitarium is just off to the right of the map shown on page 376.

On page 377, we have the site plan showing the two buildings currently provided in the 1959 appropriation. The additions this year are shown in the next few pages. Page 378 is the central flight control and range operations building. This is the building that we call our nerve center, or our communications hub, for space flight operations. The building contains extensive communications equipment, a computing facility, and data handling equipment.

Notice that there is provision for a briefing room and a satellite status control on the first floor.

The second floor consists of some offices and then the penthouse in which the mechanical refrigeration for the air-conditioning equipment, is located.

Mr. DUCANDER. What offices will be here? I notice the offices—this won't be any headquarters staff or anything like that.

Mr. TOWNSEND. No. sir. The facility at Beltsville will be entirely separate from the NASA headquarters. The local administrative offices for the center will be located in the building that is now under construction, the space projects building—referring back to page 377.

The offices here are used by the people manning this part of the center, particularly those connected with the data analysis and han-

dling groups, the machine programers, the mathematicians, and the communications personnel.

Mr. DUCANDER. I ask that, and Mr. Chairman, I call this to your attention, because you recall the committee had a little difficulty on the floor with the bill we had up for leasing headquarters space. I am sure that we don't want any of the Members, particularly those that were objecting on the floor, to be confused that this has anything to do with headquarters space whatsoever.

Mr. TOWNSEND. No, this is a field center of a type similar to Langley and Lewis and Ames.

On page 380 we have the Space Sciences Laboratory. You will recall from my talk the other day, this is the building in which we plan to conduct experimental researches in the area of the space sciences. We will have accelerators and vacuum systems and the various physical devices necessary to simulate and to prepare some of the flight instrumentation.

Mr. DUCANDER. You had something over $3 million in the 1959 budget for Beltsville.

Mr. TOWNSEND. $3.9 million, yes, sir.

Mr. DUCANDER. And you have $14 million here.

Mr. TOWNSEND. Yes, sir.

Mr. DUCANDER. How much do you estimate will be needed, then, for the project in the future?

Mr. TOWNSEND. At the present time these additional facilities complete the planned center. This center is planned to integrate with the overall space flight development program. If you will recall, there were two really basic needs for this—first, to provide additional facilities from a national point of view, particularly in the space sciences, and secondly, to provide a place for the reservoir of trained manpower to assist in the conduct of the NASA program.

Specifically, the people to monitor contract performance and to determine how well we are doing will be housed at Beltsville. It is our thesis that we can get a much better job from such personnel if they are, themselves, doing a small fraction of this work—in other words, if they are experienced and actually in the business, instead of having all of our contract monitors coming from a staff type function. We prefer they come from a laboratory type function where researches are going on, where they are very closely in touch with the progress in the field and are able to evaluate the work that is done for NASA.

Mr. DUCANDER. Where are the people now who will be doing this type of work?

Mr. TOWNSEND. There are two major groups of them. The first group of people are at the Langley Center. They are doing Project Mercury, the man-in-space program. They will be moved into this facility when the quarters are available.

The second large segment is housed presently at the Naval Research Laboratory and partly out in Silver Spring. The nucleus for this group came from the Navy's Project Vanguard, and the NRL upper atmosphere research group. There were some 200 people total that transferred from the NRL in the Vanguard and upper air research transfers. These people formed the nucleus of this other activity.

Mr. DUCANDER. The committee can understand, then, that aside

from maintenance and possibly some additional equipment in the future, this will complete Beltsville?

Mr. ABBOTT. I would like to recall Dr. Dryden's testimony on this point before the full committee the other day, which was to the effect—this is also my understanding of the situation—that this completes the center as we see the foreseeable needs at this time.

Now, the reservation here, I believe, is that if circumstances change in the whole space program in a manner which is not now foreseeable, then we do not know whether this would complete the center or not. But as we see it at the moment, this does complete the center.

Mr. TOWNSEND. This was precisely the point. This particular facility has been planned together with the program that has been presented for 1960, and is the planned program. If things go on much as we expect, this is the facility.

The space sciences laboratory has a second floor which is shown on page 381. That completes that item.

On page 382 we have the construction and installation laboratory. This building is essentially a wing of the research projects laboratory that is now under construction and provides the basic shop facilities necessary at a center of this type. This, I think, is what you would call light shopwork, highly precise metal working, the construction of delicate sensing equipments, and the sheet-metal work associated with the construction of satellite and rocket instrumentations.

It is not a heavy shop in the sense that there are large lathes or drill presses—it is not a production shop. It is what we would call an instrument shop. This building also has facilities in it for a clean room. I don't believe that is shown on these. No, it is not shown on these plans. We intend to have a clean room facility here for putting together the delicate instruments that make up the satellite and probe and rocket instrumentations.

Page 383 shows the roof and offices on a slightly higher level.

Mr. DUCANDER. That will be three buildings, then?

Mr. TOWNSEND. Three buildings, yes, sir. The rest of the request is for utility construction. In the first phase we are getting along with a temporary boiler and a temporary electrical, I guess you would call it, substation. The request here visualizes a central heating plant and associated electrical construction.

This is outlined, let's see, I think on page 386. The heating plant, the electric power, and then roads and site drainage.

There is another feature of this, that fallout shelters have to be provided in phase 2.

Mr. DUCANDER. Fallout shelters?

Mr. TOWNSEND. Yes. As I understand it, there is a regulation that new construction of this type have facilities available for the personnel to retreat to in case of atomic attack.

I regret my ignorance here, but I think it is a "WO something" or other requirement. It is in the justifications somewhere.

Mr. DUCANDER. That in Government buildings being built in the future, they should have fallout shelters.

Mr. TOWNSEND. This is my understanding, sir. I am not an expert in construction.

Mr. ABBOTT. OCDM directive, dated September 29, 1958.

Mr. MILLER. What page is that on?

Mr. ABBOTT. These shelters, however, are not individual things. It is merely that the buildings will be built to provide shelter for fallout. This is a requirement in the design of the buildings. This is on page 384. Of course, most heavily constructed buildings do provide fallout shelters in basements and lower floors. It is merely that the building design shall be such as to meet certain minimum requirements. This will, however, in some cases impose some additional cost.

Mr. MILLER. Running down on page 384, what is an "Ampex video tape recorder"?

Mr. TOWNSEND. Yes, sir. This is a recorder, very, very much similar to the new type recorders that they are using in the television industry that can actually take down the radio signals that the receiver at home reconstructs into a picture. The reason I kind of went around Robinhood's barn in my technology there is that such signals, say from a television transmitter, are very broad band. They occupy a large amount of space in the radio spectrum. Most standard tape recorders are capable only of recording the amount of information in a small spectrum. We need a recorder of the type that can take a very wide spectrum, the type of thing that is put out by a television transmitter.

This is not for recording television signals. It just happens that the machine is called Ampex video recorder. It is a commercial item that is available. Our use of it will be to receive signals from instrumentations and testing and checking out before flight that would be the equivalent in terms of the transmission through space of a video or a television signal—very broad band, lots of information in the radio carrier.

Mr. MILLER. What is a one time standard device?

Mr. TOWNSEND. It should have been written as one standard time device. This would be one of these electronic equipments that provide a standard time to a very high degree of accuracy that can be synchronized with W.W.V. and fed into the computers so we are all on the same time.

Mr. MILLER. As long as it is a standard time device but I thought it might be something used one time.

Control transmitters——

Mr. TOWNSEND. These are the transmitters that signal the satellite to do something.

Mr. MILLER. Backup transmitting equipment is used in connection with it?

Mr. TOWNSEND. Communications, sir. In case of a failure in telephone or landline equipment, we can transmit directly to one of our stations such as a minitrack station and get communications.

Mr. MILLER. You have another digital computer here. I just happen to have been out to the David Taylor Model Basin this morning. They showed us one of their computers and told us that they were so far behind in their work, they were working two shifts a day out there and that they had to do some work for people over in Pittsburgh, that there was one shift there. That struck me that although we are getting a lot of these things, there still is not any great surplus of them in Government today, is there?

Mr. TOWNSEND. That, sir, is correct. This is one of our fundamental problems, I think, in our space exploration, and that is the handling of data and the computing necessary to utilize the data.

For example, right now the Vanguard project has a facility, or rather, rents one from the IBM people that is on Pennsylvania Avenue and it has two computers in it. That facility is on three shifts. The Bureau of Standards has a fast computer and so does the Naval Ordnance Laboratory. Time on these computers is almost impossible to obtain. There is a private corporation—I forget the name, I believe they are over in Arlington or Alexandria or somewhere in there—which has one and I think they are installing a second computer; and already obtaining time is impossible.

It is a real problem. All of our fancy electronics seems to result in too much business at either end. For example, a rocket flight with little instruments aboard will produce a record, as we call it. It is a reel that would unwind about half as long as this entire room full of little wiggly traces, each one of them means something on every single point along that paper.

In the past we have put one person to work almost a whole year in weeding out all these data points and putting them on paper and then giving them to the scientists in the form of a curve.

Now, when you fly for not just a few minutes as a rocket does but for a matter of hours or even days and then tens and hundreds of days, as we are talking—you can imagine the almost bewildering amount of information that is sent back in the form of radio signals.

These we can put on tape, but the process from there to the point where the data are available to the scientist is the problem. This is where a computer comes in because each time you have a piece of information, you ask certain questions.

What does it say? What is this in relation to calibration? Where was the vehicle in space?

This in itself is a problem for a computer. We are rapidly backing ourselves into a corner, I think, on our ability to handle data.

Mr. MILLER. Yet, if we cannot get this interpreted, we may just as well have not sent——

Mr. TOWNSEND. There will be no purpose in doing it. The same thing holds true of course with wind tunnels.

They are making measurements on models. It is a tremendous saving in manpower. Or putting it really another way, you just could not tackle these problems without the machines.

Mr. MILLER. With manpower, no matter how good you are, there still is an opportunity for human error to creep in.

Mr. TOWNSEND. There is a lifetime——

Mr. MILLER. It can build up, whereas in this thing——

Mr. ABBOTT. Even if they could do it we simply could not afford it.

Mr. MILLER. I was just going down through here trying to get——

Mr. TOWNSEND. Let me go down through the rest of them because you gentleman may get questions on this.

Mr. MILLER. I think we have pretty well finished 384.

Mr. TOWNSEND. On 385 we have the specialized equipment that is going into the space science laboratory. A magnetically shielded room is a room in which we place equipment that must be very carefully shielded from the earth's magnetic field and from all disturbances

caused by the magnetic fields associated with powerlines and electrical devices. We need this because we have to calibrate these very sensitive magnetometers or devices to measure the magnetic field where it is very weak out in space.

Six leak detectors—leak detectors are devices we use to determine where in our vacuum systems we have holes. They are little mass spectrometers and they are absolutely essential because we require such a perfect vacuum that the tiniest little leak can ruin the whole experiment and finding these things is almost impossible without a machine. They are too small.

A particle accelerator is a device to accelerate particles to simulate those that we expect to encounter in space and to calibrate and to test our equipment.

A mass spectrometer is a device that tells you what types of gas are present in a mixture and how much of each gas is there. Vacuum test tanks—again this is the testing facility for our payloads. The thermal test tanks refer to the simulation of the conditions in outer space where you have a blazing sun on one side and essentially a very cold void on the other.

Balancing machines are necessary to dynamically balance or balance in motion the satellite payloads. In general, there is a spinning operation somewhere in the vehicle, and unless these things are balanced, they will start to vibrate like an unbalanced tire and could conceivably break off.

This is an attempt, of course, to very carefully balance our payload on the ground. We stop it and put a little weight in and spin it up and test it and stop it and put another little weight in until we get it perfectly balanced so it spins freely and smoothly.

Centrifuges are simply machines to test a piece of equipment at many times the force of gravity. Shake stands are devices to test a piece of equipment with the vibration that one expects during the booster rockets.

Gyro-test stands are stands to test and calibrate the accurate gyros necessary to make possible stabilized platforms in space and also of course in the vehicle guidance.

The hydraulic test stands here are test stands to check out hydraulic systems associated with the gyros.

The control is hydraulic rather than electrical.

Bench equipment for 150 at $15,000. This refers to the fact that we have found through experience that an average scientist or technician requires about $15,000 worth of equipment to get himself in the business. We are starting this facility——

Mr. MILLER. That does not mean all of these 150 units are going to be equipped alike.

Mr. TOWNSEND. No. This refers to the hand tools, the voltmeters and the various types of test equipment, oscilloscopes and the gadgets you see a scientist using. This is an average. We found that a man needs about this much in equipment to get going.

The instrument and installation laboratory, the items here are the machine tools and the photographic laboratory equipment.

Finally, the utilities, I think, are self-explanatory.

Mr. MILLER. That heating plant is comparable and the power communications—I guess those are all comparable with other like units in the district.

Mr. TOWNSEND. Yes, sir.

Mr. MILLER. Questions?

Mr. DUCANDER. No questions.

Mr. MILLER. Any objections?

All right, we will consider it approved.

Now, the Pacific Missile Range. I have got to be very careful. We have two items in here for California. I do not know what my friend over here will do. He is liable to take exception to California.

Mr. CHENOWETH. We will not take exception. We do not want you to have a monopoly on it. We want you to divide it.

Mr. MILLER. You get us another Edwards Dry Lake and we will set it up in Colorado.

Then the Pacific Missile Range.

Mr. BUCKLEY. I covered that in a presentation to the full committee yesterday but to go over it briefly, this is the only range from which we can shoot on a polar orbit now—that is, where we can shoot either directly north or directly south so that the orbit goes over the poles. This is an orbit that will be desired for many of the scientific firings. The only range from which we can fire this way is the Pacific Missile Range, because otherwise the cast-off boosters will drop on populated areas. In this case they will drop in the Pacific ocean to the south.

We plan, in carrying out these scientific experiments that were described to the full committee the other day, to use various boosters for the different jobs. In doing this and in going into the Pacific Missile Range, we will be the first to fire many of these configurations, these combinations of rockets.

In the Pacific Missile Range, as was the case in the Atlantic range, the first user has to pay for equipment going in there. This is the way the range is built up as time goes on.

The Pacific Missile Range people will provide their own tracking and local instrumentation in connection with the firing but we will have to provide the pad and the blockhouse, the launchers and the checkout equipment. There will be certain roads and utilities in that area which the Navy will provide as the housekeeping agency.

Mr. MILLER. May I ask this. About how many launching sites do they have at Vandenberg now? This is adjacent to Vandenberg, is it not, part of it? It is on the Vandenberg Reservation, is it not?

Mr. BUCKLEY. I am not sure exactly. I think the answer is four or five, sir.

Mr. MILLER. This, though, is on the Vandenberg——

Mr. BUCKLEY. No, sir. This area out there is divided into two parts, the Air Force part in the north, and the Navy part in the South. In the southern part, they left some area for the firing of scientific vehicles, and these are going to be isolated in canyons from other users of the place.

Vandenberg is the Air Force place to the north where they are firing operational missiles. There is an operational team using those pads that are firing on definite schedules every so often.

Incidentally, the pads on Vandenberg, most of them, are oriented to fire to the west because of the fact this is where the impact areas are into which they are making the test firings.

The second thing is, those are what we call hardstand pads, which are cut to the bone because they are specifically for that operational type of use, whereas our stand will have—we will be varying the second and third stage and want to be working on them. We will have a scientific package on the top end which will require work. So this is a different type of operation than the hard surface operation.

Mr. MILLER. How much more money will we eventually be asked to appropriate for this phase of it? I do not mean the outside, but at Point Arguelo?

Mr. BUCKLEY. For the launching area, sir; I think this proposal takes care of any plans we now have.

Mr. MILLER. What do we have out there now.

Mr. BUCKLEY. We have nothing. This will be our first item.

Mr. MILLER. Will this one blockhouse contain all of the office space that you need and facilities for launching?

Mr. BUCKLEY. We will not use a lot of office space. There will be assembly hangars needed. We plan it this way—if it goes beyond this, the Pacific Missile Range figures that we will have some cooperative use with others on the merging of the schedules.

Mr. ABBOTT. Again I think it is fair to say this meets our foreseeable needs.

Mr. MILLER. So this is not just the first increment of something we are going to come back to. We may have to come back to it, but as far as you know now, for what we have planned now, this meets——

Mr. ABBOTT. Yes.

Mr. DUCANDER. This is the first expenditure?

Mr. BUCKLEY. First expenditure at the Pacific Missile Range, yes.

Mr. ABBOTT. By NASA.

Mr. MILLER. Any objection?

Mr. CHENOWETH. No.

Mr. MILLER. Have you any?

Mr. DUCANDER. No.

Mr. MILLER. Various locations. This is one of those things, Judge, you may as well close your eyes and say it is all right. We do not know where they are. Are any of these classified?

Mr. ABBOTT. No, sir, we can discuss any of these with you. Mr. Buckley, will you speak to the first one?

Mr. BUCKLEY. To the full committee the other day I described the network of stations that are around the world for tracking satellites which started approximately 2 years ago. Of course, the use of these is changing. The requirements are changing. The workload is increasing. So the items that are included here are for extending and improving this network of stations.

The first item, for instance, is optical tracking equipment.

I described some optical tracking equipment to the committee the other day, but also indicated that for certain classes of satellites which are much more refined than any we have flown, which will be for geodetic purposes or for navigation purposes or experiments in relatively, very exact measurements of the orbit will be needed. These

exact measurements will be made with improved optical equipment. So, we have an item there for optical tracking equipment.

At stations that now exist, there is some telemetering receiving equipment. But the telemetering receiving equipment that is at these stations is suitable only for the Vanguard program.

The more complicated forms of telemetering that are being used as a result of the greatly increased amount of data we are trying to get will result in a requirement at these stations for augmenting the telemetering receiving equipment at each station.

I mentioned the other day that these stations were set up for orbits that were at a low angle to the equator and we are going to make changes in the antennas suitable——

Mr. MILLER. May I interrupt you here to say Judge Chenoweth was not here the other day when you showed the chart.

Just for this information, one of these stations is in Australia, three of them along the coast of South America——

Mr. BUCKLEY. I happen to have the chart here.

Mr. MILLER. Could you just set it up for the Judge?

Mr. CHENOWETH. Do not go to too much bother.

Mr. MILLER. But I think, Judge, you should see it.

Mr. CHENOWETH. I would be interested in it, very much so.

Mr. ABBOTT. I think you should see it.

Mr. MILLER. It will give a much better understanding of what we are talking about.

These are the stations around the world that catch these things in orbit.

Mr. BUCKLEY. The optical stations are all equipped with a very special camera.

Mr. MILLER. That is this optical camera.

Mr. BUCKLEY. This is tracking equipment, $600,000. That is what these are for.

There are 12 such stations that are located around the world.

Mr. CHENOWETH. What do those stations consist of?

Mr. BUCKLEY. They consist of this camera with a house over it. This camera moves with the satellites and stops and gets pictures of it against star background.

This is an old astronomy technique of taking pictures against a background, and the stars are the best grid you could possibly get for finding out exactly where it is up there.

There is a little house that goes with it, with a slide-over roof.

Mr. CHENOWETH. How much of an investment in each station, would you say, roughly?

Mr. BUCKLEY. I think it is about $750,000.

Mr. CHENOWETH. In each station?

Mr. BUCKLEY. Yes.

Mr. MILLER. In all of them, the American is in charge of it and he has four or five natives——

Mr. BUCKLEY. They tried to operate this thing from an astronomer's point of view or a scientist's point of view with only a couple of men in it. They worked them to death. That is part of our job this year, to put this on a more equitable basis.

We plan on putting five or possibly six because they were working fantastic hours.

They had personnel trouble as a result.

As to these cameras, there are other techniques that can be used in the future, we think.

We are experimenting with that. There are three or four companies in the United States that have a proposal.

One of these will result in new equipment.

Mr. CHENOWETH. Is any effort being made to keep these secret?

Mr. BUCKLEY. No. In our program, we are trying to keep this a scientific and a civilian set up.

With us, secrecy is not vital, except as required because of, say, the performance of boosters, which may be secret or something like that for the military.

Our schedules may have to be, and some of the things we use, in order to protect the experiment from foolish amateurs who try to play games with us, but in general this is wide open and that is why we can use people from the various countries.

This item 1 here is to augment and improve both the optical network and the electronic network and these are the details of the changes.

The second item covers the data acquisition station in Bermuda which is a large parabolic dish with sensitive electronic equipment. The total figure here is $1,355,000.

This receiving station will be used as a foundation down-range station for Wallops Island firings. It also is on the course of any northeast firings out of Cape Canaveral, so it will be used for that.

It is going to be used for data for devices that are already in orbit that may have been shot on other paths, that were not fired right over the station on the first path and for some of the experiments, the scientific experiments that Mr. Townsend is setting up.

This station will be tied in by communications directly to Canaveral and directly to Wallops Island.

Mr. DUCANDER. Do you lease this land from the British Government?

Mr. BUCKLEY. There are a large number of 99-year leases on Bermuda with the U.S. Government. We have investigated this and there are three sites that may be suitable. We had a site-selection team out there the first of this week. So far, this is going ahead very nicely.

Mr. MILLER. Those 99-year leases have about 85 years now to run?

Mr. BUCKLEY. Right.

Mr. MILLER. Less than that, I guess. You think, if it will last that long, we will be all right?

Mr. DUCANDER. Was this station, as I recall, to be used in any way for the Project Mercury?

Mr. BUCKLEY. Yes, sir.

Mr. DUCANDER. If something went wrong immediately, this station would be very valuable to get him out of the Atlantic before you got him too far.

Mr. BUCKLEY. Yes, sir, in addition to Project Mercury it has these other uses. In planning Project Mercury we tried to assure that we would make station choices that would have general use, so they would not be only for Mercury.

The third item here is facilities for the support of the man in space vehicles.

This Mercury program has been continuing through fiscal 1959 and 1959 supplemental and 1960, with a total of about $14.5 million. This is the increment we have down for 1960—the largest part of it is for a number of telemetering stations around the world.

There will be some 12 or 14 telemetering stations with a doctor at each one, and in each one a voice transmitter talking to the pilot in the craft, a telemetering receiving station on the ground with a place for the doctor, and the possibility of sending control signals up to the craft.

This is the largest part of this particular item.

There will be some communication links that will be necessary to tie these stations together.

We are going to use military communications to a large part in this, and secondly, we will use rented communications wherever possible so there will not be a permanent investment.

But in certain places such as Alaska, for instance—it will not be on Project Mercury—it may be necessary from lack of either commercial or military communications to have a local link transmitting out to where the station is, back and forth.

This covers some of these local links, and some parts of the communicating links that are not supplied commercially or by the military, we will have to fill in.

This is not a fixed item. We do not know where these are yet. This is in the middle of a study.

Mr. MILLER. I will say, I notice you have seven shipboard installations, $300,000 apiece.

Mr. BUCKLEY. Yes, the aeromedical people want to talk to this man every 15 minutes. You cannot now do this. So we will have to have the cooperation of the Navy to have ships spaced properly and we will have to provide the equipment for the Navy.

This equipment will be used on other projects. It will be used in other locations. This telemetering will all be very mobile so we can move it to other locations for later versions of this same project or other projects.

It is part of a very large installation of equipment.

Mr. DUCANDER. I think that is one thing to keep in mind that once they put the man in space and it is successful, or even if it is not successful, this is not going to be the only time you will be using these facilities. You just keep on using them, won't you?

Mr. MILLER. This is basic equipment, and we hope that the first man that goes up will be successful. But we will put a man in space sooner or later.

Mr. CHENOWETH. These are going to be around the world, are they, so you will be in contact with him every 15 minutes?

Mr. BUCKLEY. The aeromedical people want to talk to him for 5 minutes out of every 15. They have said 10 minutes out of every 15 a couple of times and some said we should talk to him continuously. We cannot afford probably to put in an installation to talk to him continuously. That would double the number of stations or more.

Mr. CHENOWETH. How many do you have now? You say you have not agreed on the number yet?

Mr. BUCKLEY. No, sir. The aeromedical people—there is a group of doctors that are having a very important part to play in this thing, and of course they are testing these astronauts, and as a result of the tests they will try to decide and specify these things much more closely.

Mr. CHENOWETH. You would have to put them in a number of different countries around the world, is that it?

Mr. BUCKLEY. We will put them in countries where we can, and on ships.

Mr. CHENOWETH. Do you have to get permission?

You have to get permission of the countries to do that?

Mr. BUCKLEY. That is right.

Mr. MILLER. You have permission from a good many of them, do you not?

Mr. BUCKLEY. We have permission from a good many of them where we have scientific installations and previous telemetering stations from parts of our programs that preceded this.

Mr. CHENOWETH. You have got a couple of years yet to work on that.

Mr. BUCKLEY. We hope it is not 2 years.

Mr. CHENOWETH. Isn't 1962 the target they are shooting at now?

Mr. ABBOTT. We hope it will be less than 2 years. I think it is fair to state, too, that cooperation internationally has been very good as a whole on this whole program.

Mr. MILLER. Is there any objection to this various number of locations?

Mr. DUCANDER. No, sir. Except, Mr. Chairman, I think maybe a little refreshing on the Rover project.

Mr. ABBOTT. There are some facilities——

Mr. MILLER. The $20 million, though, is OK.

Mr. CHENOWETH. Yes.

Mr. MILLER. Then that completes it, sir. Without objection——

Mr. DUCANDER. Rover is in there, Mr. Chairman.

Mr. MILLER. Is in the $20 million?

Mr. DUCANDER. Yes, sir.

Mr. MILLER. Then go ahead, excuse me.

Mr. ABBOTT. The Rover program, you will recall is now a joint program between the Atomic Energy Commission and the NASA. The Atomic Energy Commission at its Nevada test site has facilities for testing the reactor component of the nuclear rocket, but they do not have the rest of the facilities that are needed for making the complete test that will be needed for the development of such a rocket.

In particular, there are no facilities there to test the flow system of the propellant through the reactor and through the rocket nozzle and associated equipment.

The purpose of this item is to provide that equipment in the form of an electric drive system to pump the propellant through the reactor and through the nozzle, and the other equipment that is needed to study the dynamics of the complete system to permit the test of the reactor with the propellant flow.

This part of the program is our responsibility rather than that of the Atomic Energy Commission as far as providing facilities and the development of the equipment is concerned.

Mr. DUCANDER. Have there been previous appropriations to NASA for Rover?

Mr. ABBOTT. No, sir, no previous appropriations for facilities to NASA for this program.

Mr. DUCANDER. But there have been to AEC.

Mr. ABBOTT. Yes, sir.

Mr. DUCANDER. I think that other was asked the other day and perhaps you were doing this or going to submit it for the record—what AEC is being budgeted for this program?

Mr. ABBOTT. I am sorry, I do not have that figure with me. We can find out and submit it for the record.

I think the major portion of that will not be for facilities, but will be for the reactor development program.

Mr. DUCANDER. I think there is a possibility, however, that the question may be raised—how much are we spending on Rover, or something like that.

Mr. ABBOTT. We will provide that for the record.

Mr. MILLER. Will that be a continuing project? There may be more needed, more money needed for that in the future, might there not?

Mr. ABBOTT. Sir, this money that is requested here will provide this facility for the study of the flow system through the reactor. Now, as this project progresses, of course the propellant will not be pumped by electricity on the final device. It will be pumped by a pump driven by a turbine operating from the hot propellant gases. This sort of money will come out of the program development.

I cannot state definitely whether there will be any need for any further facilities or not, but this again supplies the foreseeable needs.

Mr. MILLER. Do. you have anything further?

Mr. DUCANDER. There is one more item, Mr. Chairman, to complete the $20 million, the propulsion development facilities.

Mr. ABBOTT. Mr. Heaton.

Mr. NUNN. Mr. Ducander, the same figure, the AEC expenditures on Rover, we promised to furnish it to your Subcommittee No. 2, I believe this morning; is it necessary to furnish it twice?

Are these records separate?

Mr. DUCANDER. There will be a separate record but we can get it from the other one.

Mr. MILLER. The propulsion development facility.

Colonel HEATON. I will speak to this: I covered the item before the entire committee the other day.

As shown here in the justification sheets, this item comprises three facilities—two of which are in support of advanced vehicle programs, which are, you might say, pillars of the national booster program.

Both of these facilities which are of the nature of new test stands are really indispensable to assure that we have a fully reliable and fully proven system during the development phase and also we will use the same vehicles in the stages after they are produced before they are shipped to the missile range for firing as part of the complete vehicle.

Before we decided we had to have new test stands altogether, we looked over all the possibilities of modifying stands which exist now through the country and determined we indeed had to build new ones.

One of these stands is for the Vega program, as we call it, and the other stand is for the Centaur program.

Mr. MILLER. Both of these stands will have to be much heavier than anything that is here now, will they not?

Colonel HEATON. No, they will not have to be heavier, sir. As I mentioned before the full committee, what we are testing here is a second stage that will fit on top of Atlas. So it will not be as big as the Atlas.

However, the stands have to be very complete because they will not only test a propulsion system, which is, of course, the main thing to be tested, including the tankage and the pumps within the tanks, which feed propellant through the lines to the engine-driven pump and so forth, but during the checkout of the complete stage, after it has been produced, we will also have to check the guidance equipment, control equipment, and so forth—all the elements of this stage.

So for that reason, although these are not massive structures in terms of the kinds of structures we will need, for example, to develop the large rockets, still they are complex and they are expensive.

For the Vega stand we requested $1½ million and for the Centaur stand $1¾ million.

Mr. DUCANDER. Where will these be?

Colonel HEATON. We have decided the ideal location for these two stands is a location called Sycamore Canyon, which is close to the Convair astronautics plant, San Diego, Calif. Convair, you see, is the contractor for both of these upper stages and the Atlas and they are presently occupying this Sycamore Canyon site which is a Government-owner site—just 11 miles from the Convair plant.

This location, of course, effects economies both in time and cost, and also we are fortunate in having a head start toward these facilities by reason of the fact that control blockhouses are already in existence which will preclude the necessity of our building new ones for this program.

Are there any other questions on that?

Mr. DUCANDER. I was just wondering about the central testing facility for a high energy liquid rocket.

Colonel HEATON. As I mentioned before the full committee the other day, we are deficient nationally in facilities which will permit us to test very toxic but very valuable propellants in rocket systems. These very toxic and very high energy propellants, when developed into rocket engines, will give us very marked increases in the payloads we can carry as a function of the total size of the rocket. They are particularly valuable in upper stages, the very top stages of multistage rockets.

So as we now stand, we are quite limited by reason of the facilities we have today being located near present research facilities, research institutions such as the Jet Propulsion Laboratory in California, or the Lewis Research Center of NASA in Cleveland. We have facilities that can test these types of propellants, but only very small engines, because the liberation of quantities of such things as fluorine in the atmosphere around an urban area would be completely unacceptable.

These are very nasty propellants, so we must have a relatively isolated location for their testing.

Mr. DUCANDER. Where will this facility be located?

Colonel HEATON. As mentioned the other day, we are in the stage of picking a location for this. A committee has been appointed to study the matter. This committee has yet to meet for the first time.

Mr. DUCANDER. How can you budget roads and fencing, $600,000 and site preparations, grading, drainage and trenching, $300,000, if you don't know where the site is going to be?

Colonel HEATON. That is a very good question, sir. These are typical figures which experience teaches us will be required in a relatively isolated area to provide the amount of—well, site preparation for such facilities as this, the grading, for example. This presumes that we would have an isolated somewhat desert type location where there is experience in developing such locations as, say, the Edwards rocket facilities in California. We know what the costs are there and using this as a basis we can make an estimate of the costs we will encounter in building a rudimentary facility, but a usable one.

Mr. CHENOWETH. You say the site board hasn't yet met?

Colonel HEATON. The site selection board hasn't yet met. No, sir, they have not.

Mr. CHENOWETH. What general locations are they going to consider?

Colonel HEATON. As I mentioned before the full committee, we have not limited this. We will, of course, be limited by the nature of the area we must have. It has to be isolated, of course. We will have to have an adequate water supply available. We must be in a region where it will not be too expensive to bring in adequate electric power.

These are compelling reasons. These are basic conditions or basic qualifications. There will be others which are not completely controlling, but which will be influential such as that it would be a savings of money if we could start with a basic development, partial development, of a site which already exists, using some of the supporting installations which are already installed in a remote location. This would be something we would consider, but now you see I am getting into the area of the things which this committee which has yet to convene will be weighing and I can't forecast what they will come up with.

Mr. DUCANDER. Do you have any target date for the committee to meet and make a decision?

Colonel HEATON. We have no target date yet for the committee to meet or make a decision, but I am sure that the first meetings will take place within the next month or 2 months.

Mr. MILLER. It is very hard, and you are going to find it very difficult, to approve, although we realize its essentiality, or get approval of this—I am certain that the Appropriations Committee can hardly give you a blank check for this authorization.

Colonel HEATON. I think we can say this, that within the year coming we will require a facility such as this. In other words, this is the kind of facility that is definitely required. There is no question about it, and in later years we will find need for more extensive facilities of this type. This, however, is intended to buy a usable facility.

Mr. DUCANDER. Don't you think it would be sensible or perhaps it wouldn't, but what do you think of allowing your committee to go and get their site and then let our committee report show that since

you haven't arrived at a site it would be agreeable to your coming back for a supplemental authorization when you know where it is going to be and what expenses you will be put to to erect this facility.

Mr. ABBOTT. We would hope this would not be the decision, sir, because of the possible time delays that might be involved in such a procedure. These time delays might result from any one of several things, including such matters as Congress approaching the end of a session, or perhaps not being in session at the time that we would be ready with the information.

It is accordingly more than possible that there would be a delay of some months in such a procedure as compared with going ahead immediately with authorization.

Mr. DUCANDER. Do I understand the budget implications that under the section, "Various locations" for $20 million, that you can reprogram within that any way that you want to? For instance, you could borrow some from Project Rover.

Mr. ABBOTT. Only to a very limited extent, sir. I think the recommended provision for reprograming here is a variation of 5 percent between items. This has been a provision of last year in the authorizing legislation for the NASA, and for many previous years in the authorization for construction and equipment in the NACA to permit necessary flexibility between the actual costs of these items and these estimated costs.

In some cases we overestimate a little bit, and in other cases we underestimate, but on the average, we hit it very close. This 5 percent is not very much, so we have had the provision of making this variation one way or another between individual items as long as the total amount was not exceeded.

Mr. DUCANDER. What about the provisions of the bill on page 3, line 17, section 3, which would permit you to use $5 million to construct, expand, modify laboratories or other installations? Do you think you could use some of that money?

Mr. ABBOTT. This money is provided for unforeseeable emergencies that may arise, not for reprograming of the items which are before you. This particular facility is foreseen and hence we would not consider that to be within this item of $5 million.

Mr. DUCANDER. Mr. Abbott, it doesn't say that really, does it? Perhaps I am not reading it closely enough. It says, "may be used to construct, expand, or modify laboratories and other installations if found by the Administrator to be necessary because of changes in the national program of aeronautical and space activities or new scientific or engineering developments."

Mr. ABBOTT. Yes, sir. My interpretation of this—and I am not a lawyer, of course—is that this says that, "If found necessary because of changes in the program, or because of new scientific or engineering developments." These, because they would be changes, are new developments that we do not now foresee. There is no intent here to make any change in the program which is before you in excess of the 5 percent variation within the total program covered above.

Mr. DUCANDER. Perhaps if we added the words "because of changes or additions," it would clarify it.

Mr. ABBOTT. That might clarify it.

Mr. DUCANDER. Of course, this, I point out, Mr. Chairman, is a new figure. The figure in the supplemental bill was $500,000, was it not?

Colonel HEATON. For what?

Mr. DUCANDER. This wasn't even in, or was it?

Colonel HEATON. This was not in the 1959 supplemental.

Mr. DUCANDER. By committee amendment.

Colonel HEATON. I am not sure about that, but there was an item in the fiscal 1959 supplemental under this heading but it didn't pertain to this facility.

Mr. DUCANDER. Not to this facility. I am speaking to this language in the bill on page 3, line 17. Didn't we in the fiscal 1959 supplemental——

Mr. NUNN. That is correct, Mr. Ducander. There was a similar provision to the extent of $500,000, a similar provision. It was not precisely this provision.

Mr. DUCANDER. But the committee amendment required NASA to report back to the committee if it was used.

Mr. NUNN. Notify the committee.

Mr. DUCANDER. In this case they increased it to $5 million.

Mr. ABBOTT. This retains that provision, and the intent here is to provide for emergencies which are not now foreseen by providing authorizations to expend up to $5 million.

You will note, however, that this $5 million would not exceed the total amount of the budget. The intent of the wording on the last page, as I understand it, "providing further"—skipping some of the language, "additional appropriations are hereby authorized for the purposes of this section in the amount of $5 million," to provide us authorization at the time the emergencies arose which required us, with the President's authorization, to come back for an emergency appropriation.

Mr. DUCANDER. In total money to NASA, you would get an extra $5 million if you exercised this section.

Mr. ABBOTT. Only if we had approval of the Bureau of the Budget and returned to the Congress for the extra $5 million.

Mr. DUCANDER. To the Appropriations Committee?

Mr. ABBOTT. Yes. This provides the authorization to reduce the time that might be required to get the extra $5 million if we did have to have it.

Colonel HEATON. I would like to say, sir, reiterate actually, that we feel that this facility is one we definitely will need. It is a fundamental start. It is a complete facility in the sense we can use it, but I am sure that we are going to be back on future occasions for more of this type of thing. This, however, is a complete thing, and because we know that we will need at least this in 1960, we felt it was appropriate to put it in this budget.

Mr. MILLER. When do you think this bill will come on the floor? Have you any idea?

Mr. DUCANDER. It can't come, Mr. Chairman—he doesn't plan to have a full committee meeting until Tuesday. I doubt seriously that one or two of the subcommittees can report on Tuesday. That is, it has so been reported to me. So perhaps it will be Wednesday or Thursday before the full committee can take it up.

I suspect that there will be considerable debate in the full committee on this section 3 where this $5 million has been put in instead of the $500,000 that we were accustomed to in the fiscal year 1959 supplemental.

Afater that, of course, a report has to be written and the hearings printed. We will apply for a hearing before the Rules Committee, which couldn't come before the latter part of the following week.

Mr. MILLER. When do you think your committee will report? You say a month?

Colonel HEATON. I feel within the month they could convene, but before they could report, sir, I feel it would be a number of months because the committee must consider very many possible sites before we can arrive at this decision.

So we feel the construction will begin and funds will be required in fiscal 1960, but we do not anticipate a decision——

Mr. MILLER. There will be at least two supplementals before we get out of here. There is always a supplemental the last week or so.

Mr. DUCANDER. One reason for raising this matter was not to be picky about it, but I echo what Mr. Miller has said, that I wonder, if this committee did just blankly authorize it, if the Appropriations Committee wouldn't bring this up just as it has been brought up at this meeting.

I am a little afraid that it puts this committee in the position of granting, you might say, a blank check for this matter here, and the Appropriations Committee saying, "Well, that is the way they do business down there." We really go over these things, you see.

Mr. ABBOTT. I appreciate the points you raise very much, and I think they are valid points. I would like to point out, however, in support of what Mr. Heaton just said about the need for this facility, that it is not a blank check. This is a facility we know we need, we know we need it in about this amount and we know about how much this amount of money will buy.

The item of uncertainty about it is the location, and I think only the location. That is the only item of uncertainty. You may quite well be right about the reaction of the Appropriations Committee. Your reaction to that would probably be much better informed than mine.

However, again, in the interest of saving time, we would appreciate it very much if this committee could approve this item so that even if the Appropriations Committee did take such action as you say, it would be necessary then only to go back to them instead of going first to you and then to them, which invariably involves some loss of time after we would be ready to move on the item.

Mr. DUCANDER. Mr. Abbott, that usually hurts the feelings of the authorizing committee.

Mr. ABBOTT. I regret that very much, and it is certainly not my intent to do so.

Mr. MILLER. You have items in here—for instance, your water system, your electric power system. Assuming that the other things are right, depending on where you put these things, those are going to be quite variable.

Colonel HEATON. That is true. The quantity of the water will not be variable.

Mr. MILLER. You will need it.

Colonel HEATON. The length of pipes and so forth might.

Mr. MILLER. There are places, I am sure, where you want a million gallons of water a day, which is 20 acre-feet. You would have a pretty hard time getting it. You might find the site you want is going to cost you a lot more than that—another one a lot less, depending on where it is, and the facilities.

Colonel HEATON. That is right, sir.

Mr. MILLER. In other words, I appreciate the necessity for doing this, but in trying to make the estimate—certain of the things, test cells—maybe you can put a definite figure on them. But there are a number of things in here that are heavy. You have to go up in order to protect yourself on them. I just wonder if you did wait until your committee reported, this $4,750,000 may be $3,500,000.

Colonel HEATON. Sir, we had to make some presumption, of course, to establish any dollar figure.

Mr. MILLER. That is right. On the other hand, this $4,700,000 may be $6 million.

Colonel HEATON. It is true that it could be somewhat larger. I feel that this is the minimum for which we can buy a usable facility. Of course, we have to, as I say, presume a type of a location. The type of a location that was presumed is one where we could utilize certain basic facilities that are already in the region and where we had to assume only certain lengths of piping to get the water to the facility. We had to presume that not very far from the facility would be a substation into which we could tap to get adequate power supplies.

So if we were to select a location that is not only remote and isolated from the population centers, but into which there is not presently power supplies available that we can tap, or where we would have to go some very considerable distance for water, costs certainly would go up. Also this would be the case if we had to bring in considerable distances of roads just to get access to the facility.

This is the minimum cost we feel we will be put to to get a facility which will give us the type of capability we want here—namely, one test cell able to contain and test an engine of 100,000 pounds of thrust for these very toxic propellants.

Mr. CHENOWETH. What type of a place are you looking for? Do you have anything particular in mind?

Colonel HEATON. Well, sir, normally we look for a rather arid climate. Also we would prefer, as I say, for cost reasons, to be close to an existing installation, Government installations, of some sort into which we can link our water and our electric supplies and use existing roads and base facilities.

Mr. CHENOWETH. You want to be isolated, you say?

Colonel HEATON. Yes, sir, we want to be isolated from a distance standpoint from centers of population, but we don't want to be isolated from high tension powerlines and from sources of water.

Mr. CHENOWETH. How much land will be required?

Colonel HEATON. For this basic facility here I don't recall exactly how we did figure, but land we did not consider to be a factor. We intended to use existing Government-owned property on which to build this facility.

Mr. DUCANDER. That is why you didn't put anything for land in?

Colonel HEATON. That is right, sir.

Mr. CHENOWETH. You don't want to build all these facilities right together, do you? Don't you want to disperse them to a certain extent?

Colonel HEATON. Yes, they would be dispersed, sir, sufficiently dispersed from other facilities so that the operation of this facility wouldn't endanger the other facilities.

Mr. CHENOWETH. I was just thinking, instead of putting everything into southern California, you might want to come over to southern Colorado.

Colonel HEATON. I could see that coming, sir.

Mr. DUCANDER. How much isolation do you require?

Colonel HEATON. From a center of population for these facilities, I feel of the order of 10 miles.

Mr. DUCANDER. How close could you be to a Government facility? Nothing like this could be handled at Cape Canaveral or the Pacific Missile Range?

Colonel HEATON. No, sir, not at the ranges. It could be handled—this isn't meant to imply this is where it will be, but it could be handled at the rocket test station at Edwards in California. There is enough area there and it does have such things as availabe water supplies and power supplies, and it is sufficiently isolated, not only by distance, but also because of topography, we can sufficiently isolate these toxic stands from others so they won't endanger the others.

There would be some days possibly because of temperature inversions, or because of adverse wind directions, that they would have to suspend operations, but this would be rare in a location such as that. That is just an example of the kind of thing you look for.

Mr. CHENOWETH. How many people will be employed in this operation?

Colonel HEATON. For the one we have here, a rudimentary facility, it will be small in number, probably not more than, say, 20.

Mr. CHENOWETH. None of them will live on the facility? They will live some distance away?

Mr. ABBOTT. Yes, sir, and they move in to work. I might point out that facilities of this type are not very desirable neighborhoods. This fluorine is very nasty stuff if it gets loose. Consequently you need to be a long way away from other things. These facilities do not employ very many people. I can't help but draw a comparison between these and, for instance, some types of oil refinery plants. I remember talking rather extensively at one time with a vice president of one of our larger oil companies immediately after he had just succeeded, after a lot of difficulty, in finding a location for an oil refinery on the east coast. The company had explored practically the whole coast and could find no community that would even have the thing. However, they did finally succeed in finding a community which had had no experience with oil refineries and were welcomed with open arms, whereupon he was amazed, because such oil refineries are a nuisance. The chief employment is during the construction of them. After that the employment is so small they add very little to the economy of the area, but they certainly do continue to provide a nuisance for year after year after year.

I think many of these same considerations apply to this sort of thing. As far as I am concerned, I would like to have a thing like this as far away from where I live as I could get it.

Mr. MILLER. We have a big liquid carbonic plant out in Oakland that looks like something—this fellow who used to draw all of these fine cartoons, but it only employs three people. It is all automatic.

We will take that last provision under advisement. We will discuss it with the chairman of the committee to see how he feels about it. After all, he is the man who has to do most of the defending of the bill on the floor.

Thank you very much, gentlemen. It has been not only interesting, it is rather sort of history-making to participate in the first budget for NASA.

(Whereupon, at 4:17 p.m., the subcommittee adjourned.)

1960 NASA AUTHORIZATION

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON SCIENTIFIC RESEARCH
AND DEVELOPMENT (SUBCOMMITTEE No. 2),
Washington, D.C., Friday, April 24, 1959.

EXECUTIVE SESSION

The subcommittee met at 10:30 a.m., Hon. Olin E. Teague (chairman of the subcommittee) presiding.

Witnesses present from the National Aeronautics and Space Administration were: Dr. Hugh L. Dryden, Deputy Administrator; D. D. Wyatt, Assistant to the Director, Space Flight Development; Dr. Homer Newell, Assistant Director for Space Sciences; E. M. Cortright, Chief of Advanced Technology, Office of Space Flight Development; M. B. Ames, Chief, Flight Mechanics Research Division; A. F. Siepert, Director, Office of Business Administration.

Mr. TEAGUE. As I understand the purpose of our hearings, this is a case of a subcommittee handling parts of NASA's authorization in committee and on the floor. Mr. Yeager, as I understand it, it is the first four——

Mr. YEAGER. Yes, sir; the first four major R. & D. categories.

Mr. TEAGUE. Mr. Wolf, have you had a chance to check these requests on page 201?

Mr. WOLF. We have been religiously going to the hearings.

Mr. TEAGUE. Well, I religiously read this before 1 o'clock this morning. Mr. Wyatt, last night I took each of these projects to go through and read what you have written in here.

Mr. WYATT. Yes, sir.

Mr. TEAGUE. No, starting with that basis, suppose we go through it again and check it. Let us turn to page 207, for example.

Mr. WYATT. Yes, sir.

Mr. TEAGUE. Actually, you describe the objectives in each one of these and then you go to the justification?

Mr. WYATT. Yes, sir.

Mr. TEAGUE. Do you people have something different or more detailed to give us than what is already in this book?

Mr. WYATT. In response to any questions you might have. That is our purpose in being here, to verify it for you.

Mr. TEAGUE. My biggest problem is understanding some of the terms and what they mean. Because some members of Congress are going to get up and ask about them. Mr. Wyatt, would you work out a statement for us clarifying the scientific basis for your program?

Mr. WYATT. We can do that, I am sure, sir.
(Material requested follows:)

SCIENTIFIC INVESTIGATIONS IN SPACE

Space science, as used here, is simply a convenient phrase to mean scientific research conducted in outer space. It is fundamental research with the principal objective of extending the frontiers of knowledge about the earth's upper atmosphere and outer space.

It was such basic research in the past that laid the groundwork for such practical applications as meteorological and communications satellites, now under development. It is such fundamental research in the present that is required to lay the groundwork for future applications, one or two decades hence. Space research is also necessary to support various activities in space, such as the placing of man in space, the development and use of an orbiting manned laboratory, and the instrumented or manned exploration of the moon and planets.

The vehicles for space research are sounding rockets, satellites, and space probes. The sounding rocket is arbitrarily defined as a vehicle which follows a more or less vertical trajectory out to a distance of not more than one earth's radius, that is 4,000 miles above the surface of the earth, and then falls directly back to the ground. When the payload is so launched that it continues to orbit a number of times about the earth, then it is called an artificial satellite. If the payload is propected more than 4,000 miles from the earth's surface and does not become an earth satellite, then it is called a space probe. Included in such vehicles must be special power supplies, radio equipment, and automatic instruments to measure and relay back to earth the information sought.

In the total program areas included in this category, contracts have been placed with: Aerojet General Corp., California; Ordnance (Army); Itex Corp., Massachusetts; Naval Research Laboratory (ONR-Navy); New York University; Aerolab Development Co., California; Ballistic Missile Division (ARDC-Air Force); Army Ordnance Missile Command; Bureau of Standards (Commerce); Alton Engineering Co., Maryland; Iowa State University; Massachusetts Institute of Technology; University of Minnesota; Naval Ordnance Test Station (ONR-Navy); Army Ballistic Missile Agency; Jet Propulsion Laboratory (Cal. Tech.); Corps of Engineers (Army); University of Chicago, Illinois.

Mr. TEAGUE. Mr. Yeager, we have to write a report, don't we?

Mr. YEAGER. Yes, sir. What the chairman wants, essentially, though, is a report to the committee, saying that we have gone over these items and they are satisfactory to the subcommittee.

Mr. WOLF. With the chairman's permission.

Mr. TEAGUE. Mr. Wolf.

Mr. WOLF. I would like to ask—I am sure this question is going to come up. How much has been cut from the original suggested amount that you wanted for each of these projects? Some member is going to ask this on the floor, and why is this lesser amount now satisfactory?

Mr. TEAGUE. They are going to ask you how you know that this amount is right. Now, this is a new organization. There is no history to it.

Mr. WYATT. That is correct, sir.

Mr. TEAGUE. And they are going to ask you how do you know this $16 million, for example, is a proper amount.

Mr. WYATT. May I ask Dr. Dryden.

Dr. DRYDEN. May I review the history of this? I mean the history of the way in which these numbers have been set down.

Mr. WOLF. We want a simple answer that we can use.

Dr. DRYDEN. Yes. I will give you the history briefly. NASA itself did not come into existence until October 1. There had been appropriated——

Mr. TEAGUE. As a result of your authorization bill last year?

Dr. DRYDEN. Last year.

Mr. TEAGUE. July.

Dr. DRYDEN. Before that time, at the earlier session of Congress, an appropriation for NACA had been passed—in the same session of Congress, I am sorry, but the NACA appropriation had been passed and a sum for NASA was introduced and defended before the then Space Committees and Appropriations Committees. An amount of $80 million was appropriated by Congress in that supplemental.

When the President set up NASA he transferred into it by Executive order from the Department of Defense some activities and moneys. The moneys were of the order of $117 million which had been appropriated in the Defense Department appropriation. That accounts for the moneys that were appropriated for the fiscal year just ended, that is, will be ended on July 1.

In September, the Budget Bureau asked for an estimate for NASA for the next year. That was before Dr. Glennan was appointed. And under instructions from the President the NACA, which was the body then in existence, sent a simple letter with a line estimate of $623 million to the Budget Bureau as the best estimate that could be made at that time of what the requirements would be. This was based on rather hasty program planning.

Mr. TEAGUE. New people in new jobs?

Dr. DRYDEN. New people involved. It was the best we could do.

Dr. Glennan had this letter put in front of him the first day he was in office, to sign and transmit to the Budget Bureau. He obviously did this without any opportunity to review the background.

Also by direction of the President, we had initiated some time before discussions of our program in relation to the defense program, in particular with the program of ARPA. Those first discussions showed right away that there was some duplication in programing.

As a result of this, a meeting was set up, chairmaned by Dr. Killian, and attended by Mr. Quarles and Roy Johnson and one or two others on the defense side, and by Dr. Glennan, myself, and Dr. Silverstein, and one or two members of the staff, to discuss these duplications and remove them.

We identified I believe—I don't have the notes with me—about 60 to 70 million of actual duplication. For example, we had both budgeted for the clustered engine project that is now being run by Army Ballistic Missile Agency and obviously we didn't want to send Congress two budgets having the same item.

So that immediately reduced our original estimate to somewhere around $560 million. I can get the exact figures.

Mr. ULMER. $523.6 million was the formal request to the Bureau of the Budget.

Dr. DRYDEN. There continued a discussion of the program. At no place in this discussion was a ceiling suggested by anybody. It was a discussion of the merits of the various items in these programs, to come down to what looked like a proper program for the country, considering both the defense or ARPA program and our own.

As a result of this discussion, we formally submitted a request for $485,300,000, with a backup of what went behind those numbers, and

the Budget Bureau approved that figure. The President transmitted it to Congress.

Mr. TEAGUE. A question.

Mr. WOLF. What happened to the $523 million? How do you arrive, then, at $485 million?

Dr. DRYDEN. By discussion of the merits of the various items in the program, whether it made sense to do this thing at this time.

Mr. TEAGUE. They said they found a duplication of $60 million.

Dr. DRYDEN. Part of it was further discussion by the parties that I have mentioned, of what made——

Mr. WOLF. Your original figure, that is the rough beginning estimate, was $623 million?

Dr. DRYDEN. That is right.

Mr. WOLF. You immediately, by going over the budget and checking out duplications, were able to drop it $100 million?

Dr. DRYDEN. Immediately in this case means 2½ months because this detail was not transmitted to the Budget until considerably later, you see.

Mr. WOLF. Then you found that after further discussion, after your first formal request?

Dr. DRYDEN. That is right.

Mr. WOLF. A place where you could save another $60 million.

Dr. DRYDEN. Now, throughout this we made these decisions with this statement and reservation, that whenever we found that we were getting into trouble and needed more funds we would be coming back through channels to Congress for more.

Now, if you recall the history of the first appropriation, Congress had reduced our request by $50 million, with a statement that "If you need more come back." We have come back with the 1959 supplemental, for almost the same amount, although in detail it is not exactly the same. And this is before the Congress now.

And in your subcommittee there appeared the item of $20 million something in one of the items in the 1959 supplemental.

Well, to continue on the figures, the way in which the numbers are arrived at, of course, depends on the particular item. I think Mr. Wyatt could do this in any case.

In the case of NACA laboratories which were transferred to the new agencies, and continued, we had quite a basis of experience, back experience.

In the case of estimates for developing a rocket, we consulted people in the Department of Defense and in some of the commercial companies, asking them for their experience—what kind of an estimate did they have as to how much money it would take to do this job. Just consulting various people to supplement our own experience.

Perhaps this is enough for a general statement as to how you get at these figures. They, of course, are not based on contracts in every case.

Mr. WOLF. You are satisfied that you have enough money?

Dr. DRYDEN. We are satisfied that they are reasonable estimates, and we have enough money to proceed with the program as we see it now. If we don't, we will be back before you when you come back in the spring, suggesting more if we find that we need it.

Mr. TEAGUE. Now, Doctor, after you people in your own shop went through this and cut it down, what happened then between you and the Bureau of the Budget?

Dr. DRYDEN. The Budget examiners spent 2 or 3 days with our people, much in the same way that you are doing now, going over and discussing the various items.

Am I right, Ralph? There was no adjustment?

Mr. ULMER. Well, that discussion is what resulted in the change of the overall figure from 523.8 to 485.3.

Mr. KARTH. I was going to say there was a discrepancy there of about $35 million.

Dr. DRYDEN. That is right.

Mr. ULMER. That was a result of that meeting.

(Discussion off the record.)

Dr. DRYDEN. A considerable fraction of this money is required for the long leadtime items.

We have taken it as a policy of the Congress and the policy of the administration that you desire that this country be a leader in space technology.

Now, this is a program which we think will bring us into that position. All of the items in it are necessary.

Mr. KARTH. Doctor, at this point could you specify and will you have put in the record later on, those things that are connected with long leadtimes and the amounts of money connected therewith?

(Material requested follows:)

RECORD OF LONG LEADTIME ITEMS

The NASA 1960 budget involves leadtime financing in many of its program areas. The longest leadtimes are associated with items under consideration by one of the other subcommittees, such as the development of new vehicle and propulsion systems, and research into the feasibility of advanced space devices. In the projects before this subcommittee, the leadtime items are generally of 1 to 2 years' lead and are primarily associated with (1) complex scientific and research equipment needed in instrument payloads for future flights, and (2) the flight hardware, instruments, and ground equipment for Project Mercury.

For example, in the programs under the general heading, "Scientific Investigations in Space," about 14 payloads will be financed with funds from fiscal year 1960 funds, but will not be flown before fiscal year 1961. The aggregate sums of 1960 money to be expended on these payloads will be about $18 million.

Several meteorological and communication system payloads will also be financed from fiscal year 1960 moneys for flights in fiscal year 1961. A total of $7 million of fiscal year 1960 moneys will be applied to these payloads.

The manned space flight program (Project Mercury) is expected to cost a total of about $128 million. Approximately $37,700,000 has been provided in the fiscal year 1959 budget. An additional $20,750,000 has been requested in a supplemental for 1959 budget and $70 million in the 1960 budget. These latter two sums, totaling about $91 million, will largely be expended for items to be flown in fiscal years 1961 and 1962.

Dr. DRYDEN. Yes. I think they are principally in the part of this being handled by the other subcommittee, the vehicle development and space propulsion technology. But there may be some items——

Mr. KARTH. We have the manned space items here.

Mr. WYATT. Definitely, and in the scientific investigations there are payloads there that have a lead time of up to 2 years.

Mr. KARTH. You would take into consideration and put it in the record, so we can read the transcript later on, and have this in it.

Dr. DRYDEN. You will find, sir, in the record of the full committee hearing, in the original testimony of Dr. Silverstein—he started with the scheduled firings that are planned in these various programs,

showing what vehicles you needed in order to make those firings, and when you had to start those vehicles in order to do this.

Mr. KARTH. A great deal of that overall presentation may fall within the jurisdiction of the subcommittee, you said.

Dr. DRYDEN. Yes.

Mr. TEAGUE. Doctor, I want to make another suggestion to you. You know a lot of people come before Congress and if they can word things in a way that nobody can understand, they think maybe it will be better. In NASA's case the simpler the language and the more explanatory it can be, instead of using words that 99 percent of the Members won't know—I think you will be a lot better off. In your book here you have much of that, where you go through and read a sentence, and still not know what you are talking about. If they get suspicious of that it will cause you a lot of trouble.

I would like, not only here but all the way through, when you are talking to people who aren't engineers or aren't scientists, that you try to use as near layman's language as you possibly can. That was the first thing that hit me when I started on the committee, witnesses saying things over most of our heads. And I am sure it applies to other Members of Congress.

Dr. DRYDEN. This is a difficulty with any highly technical subject, to state it in terms that the ordinary person understands.

Mr. TEAGUE. But I do think, Dr. Dryden, that the language could be simplified a whole lot, so that somebody who takes this and reads it will know more about it than I knew when I got through reading it. There are just so many technical terms and things in there that I don't know.

Mr. WOLF. There is one idea——

Mr. TEAGUE. In fact, many of them aren't in the dictionary. You can't find them.

Dr. DRYDEN. That is what you have in a new field like space. You are perfectly correct, that one of the things we are trying to do is compile a kind of a glossary of new words. Your committee has been active in this endeavor, also.

Mr. TEAGUE. Mr. Wolf.

Mr. WOLF. This has perhaps nothing and perhaps quite a bit to do with this. But there has been some publicity on these various overlapping agencies. There has been some unfavorable publicity. I am wondering if this might find its way into debate on the bill. This [holding document] happens to be from the Des Moines Tribune, but it wouldn't make any difference. This is a national syndicated article concerning overlapping agencies.

Dr. DRYDEN. I think I would like to make a statement.

Mr. WOLF. I would like to have something in my hands to use when this comes up. Because I anticipate it.

Dr. DRYDEN. I think a lot of the misunderstanding comes from the difficulty in distinguishing between agencies that have decision-making powers, operating powers, and those that are advisory.

I expect if you had an organization chart of any large company like A.T. & T., with all of their staff committees and finance committee, and the investment committee, and the committee of this, that, and the other, it would look like an extremely complicated and unworkable organization.

Actually, in the space business there are two operating agencies, NASA and the Department of Defense. Congress decided to set up a civilian agency to emphasize the civilian uses of space, and with the additional function of supporting the military developments in space as the old NACA supported military developments in aeronautics. They decided that the Defense Department should have the responsibility for military weapons systems.

These now are the only two agencies that have operating and decisionmaking desponsibilities.

Space, of course, is an attractive field and everybody likes to feel that they have some connection.

The work done in many places has some bearing on space. Take the Bureau of Standards. They have a central radio propagation laboratory studying the transmission of radio waves. Space people are interested in the transmission of radio waves, but the work of the Bureau of Standards is doing is not anything peculiar to space or related to space. It does in a way support the space effort.

Take the aeromedical activities of the services for pilots of high speed aircraft. They have to operate in pressure suits and G-suits. The space environment differs very little from the environment of high-speed airplanes, and a great deal of research is applicable.

Now, there are some new things in space, like this weightlessness. But a lot of the research of these other agencies contributes, but they are not involved in deciding on the space program and what is to be done. There are only two agencies.

Now, you do get into the complication that in the Department of Defense there is a very complex administrative organization and there are some problems relating to the relative responsibilities of the Air Force, ARPA, and if you like, the Secretary of Defense, and the three services. That, however, is a matter wholly within the Department of Defense, and within their control, the way in which space activities are to be handled within the Department of Defense.

Now, what happens when two agencies don't agree? I am sure that you gentlemen know around the Government that there are many cabinet departments that have areas that impinge on another department. Agriculture and Interior get into discussions. And the mechanism is, it is up to the President through himself and his staff to settle those things.

In the case of the space business, this has been a little more formalized because the President has been given some advisers in the form of a Space Council. But to me the organization is as simple as it can be. Granted that Congress as a policy wishes to set up a civilian organiaztion to go into space for peaceful purposes—applications to commercial communications, weather forecasting of the Weather Bureau to the scientific investigations. The rest of the apparent complication are groups whose function is advisory. And you need this in this particular group.

You mentioned the terms here that you do not understand. I can assure you that if you take two groups of technical people in quite different fields—let us take the electronics chap and the rocket propulsion expert. They run into words they don't understand, because each of these fields is highly specialized.

So any administrative group wishes the professional advice of the rocket people on rocket problems, and of the electronics people on electronics problem. When you put all this on an organization chart it looks like a hopeless mess.

Well, my feeling is that it isn't. You have two operating agencies, two people to make decisions.

There is a point of contact of common interest where friction can arise and disputes. The mechanism that can settle this is the mechanism of the President, which works in every other field.

Mr. WOLF. Well, within the military you have the Navy, the Air Force, and the Army.

Dr. DRYDEN. That is correct.

Mr. WOLF. Doing basic research. It looks to me like there is an overlapping of some of the responsibilities.

Dr. DRYDEN. You have a problem within the organization of the Department of Defense. It is a separate problem, and it is not only space, I can assure you.

Mr. KARTH. Mr. Chairman, it seems to me, though, that the question is going to be raised, despite the fact that you have a very nicely put explanation of the duties of NASA and the duties of the military being two separate and distinct parts, and those being really the only two. Because in this bill we are going to be talking about the Jet Propulsion Laboratory, for example, and this can very well bring——

Dr. DRYDEN. I didn't say they were completely separate and distinct. I said NASA was emphasizing one in which there was a point of contact and a point of possible friction.

Mr. WOLF. Yes. I am not trying to make a play on words here.

Dr. DRYDEN. No.

Mr. WOLF. But there are going to be some questions, I am sure, about this whole thing, and that we probably are getting into the field of military as a result of this budget request on jet propulsion.

Dr. DRYDEN. You see, this could be interpreted to include our whole economy. You can take over the textile industry to make uniforms. In the aeronautics field, the aeronautics research has been very largely carried out in the civilian agency, the old NACA. The military has applied the results of this to vehicles. NACA never designed an airplane. They merely furnished the information. They kept the knowledge ahead of the immediate need of the military.

In nuclear energy, you have a civilian agency, the AEC. I don't think we can argue that everything necessarily has to be within the military.

You do want to distinguish the function. And we would regard our function as first the research and development which supports the military in aeronautics and space. We have the operating function of exploring space, of space science.

Mr. WOLF. I think you are getting a little closer to the proper answer there.

Dr. DRYDEN. Now, the one place of common interest, and this again you already have in the Government, and that is the weather. There is the Weather Bureau, and there is a weather service in the military. The NASA effort is to be directed toward the civilian forecasting and use of weather. It will have a benefit for the military. Certain-

ly we must see that NASA and DOD do not have duplicating programs in that area.

So there are a number of these areas where they come together, which must be coordinated.

So I didn't say that they were completely separate and distinct, but each does have for itself a distinct function. The military develop military applications.

The reconnaissance satellite is clearly in the military. NASA should not undertake the development of a reconnaissance satellite, should not undertake the development of an infrared earily warning system. We should undertake the use of satellites in getting this information about the space environment which is needed before exploitation by either ourselves or the military.

You will recall the discovery with the very first satellites of this radiation belt, in which there is a radiation which is harmful to man if he stays in it long enough. It also will spoil photographic film. It will spoil transistors if they stay in there long enough. We have to know what is in space before you can design vehicles either for military or for peaceful applications.

Mr. TEAGUE. Dr. Dryden——

Dr. DRYDEN. I am talking too long, I am sorry.

Mr. KARTH. That is all right.

Dr. DRYDEN. I am making speeches.

Mr. TEAGUE. Mr. Gleason has suggested that you have men here who are intimately informed.

Dr. DRYDEN. On every detail.

Mr. TEAGUE. On each one of these items. Suppose we take each of the items and let somebody devote about two or three minutes on each one of them. What would you think about that?

Mr. KARTH. Fine.

Mr. TEAGUE. Mr. Bass?

Mr. BASS. That sounds like a good approach.

Mr. TEAGUE. Suppose we let you people start out and tell us which one you are going to talk about, and what page it is on.

Mr. WYATT. All right. Suppose we start in order, with the support of the NASA plant, under Aircraft Missile and Space Craft Research, on page 205, and subsequent pages.

I will ask Mr. Albert Siepert, Director of Business Administration in our headquarters, to discuss this for you.

Mr. KARTH. Mr. Chairman, I might suggest that they do not keep to the script, because this we can read.

Mr. WYATT. No, we will not be simply reading into the record what we have given you. We will try to give you a little explanation of what these items are, beyond these writeups.

Mr. SIEPERT. It might be well for me to start an explanation on this because this represents a change in our appropriation structure this year. I think the committee should understand that.

The research and development appropriation, of which this subcommittee is considering the first half, has within it this first item known as Operation of the NASA Plant.

This item supports in-house research work, that has been done for many years in what were previously the NACA laboratories.

It also supports the new in-house research work in the field of space, which is being started with this year's appropriation, and the one that is now before you.

Certain items which previously were carried in a single appropriation, salaries and expenses, have been transferred into this particular item we are considering. They were transferred into the R. & D. item because they represent kinds of things where the efficient expenditure of these moneys goes best if they are on a no-year appropriation rather than of the kind that lapses June 30th each year.

Mr. TEAGUE. Give us an example of what you are talking about.

Mr. SIEPERT. Well, for instance, within this item you will find major alterations or ordering of equipment that has a long fabrication or lead time. These laboratories represent to the Government an investment of a third of a billion dollars, or more, and alterations and modernization of these facilities can run into quite a lead time.

Mr. KARTH. You mean because certain phases of our space program becomes obsolete almost on a day by day basis?

Mr. SIEPERT. Yes.

Mr. KARTH. That is what you are talking about?

Mr. SIEPERT. Yes. I want to be sure I am not unintentionally confusing the committee.

There are two kinds of updating of facilities, and we make really a break between minor and major improvements, and the cutoff under the act is $250,000.

If these cost more than a quarter of a million dollars, we have put them in the "Construction and equipment" appropriation. You have a subcommittee looking at those items project by project.

Within these pages here, we have justified the minor alterations of smaller amounts than that.

Mr. TEAGUE. Like changing a wind tunnel.

Mr. SIEPERT. That is right.

Now, a similar item that has been put in here is called "Research Contracts." You will doubtless have some questions later to ask of this. These contracts support work in educational institutions. It is straight out-and-out research, in the academic or nonprofit institutional area. This can more properly be programed on a no-year basis.

So the recurring monthly expenditures are all under the salaries and expense item which is being separately considered; the ones that logically lap over from one year to the next, these are in the item that we are discussing with you here.

Now, on the operation of the NASA plant, there has been quite a lot of material submitted, with the committee staff's consideration, that outlines what the specific items are. I am conscious of your comment, Mr. Teague, that some of the items that describe these facilities also may need some definition, such as the mach 13 ceramic heating jet.

Mr. TEAGUE. Yes.

Mr. SIEPERT. How does this fit into the picture? We brought Mr. Ames here—or Dr. Dryden would be pleased to answer the utility of any of those particular items.

I can assure you each has an integral and planned part in terms of making our facility useful in 1960 for a particular piece of aeronautical or space research work.

I would like specifically in justification of the equipment and supplies item to mention that this is a matter——

Mr. KARTH. Mr. Chairman, may I interrupt at this point?

Mr. TEAGUE. Mr. Karth.

Mr. KARTH. I notice on page 207, repairs and alterations.

Mr. SIEPERT. Yes.

Mr. KARTH. Now, you have under "Salaries and expenses," $1,055,270. Are we going to get somewhat of a breakdown of this, to give the number of employees?

Mr. TEAGUE. That is 1959.

Mr. WYATT. That was under 1959 accounting.

Mr. KARTH. Oh.

Mr. SIEPERT. This shows how it was arrived at. Now, the comparison total—if you will take the third column of 1959, $1,165,270.

Mr. KARTH. Yes.

Mr. SIEPERT. This is the comparable figure. All we have done is put these two items which were in two pockets.

Mr. KARTH. Yes.

Mr. SIEPERT. We have now lumped them into one pocket for simplicity's sake and are justifying them under the research and development program.

Dr. DRYDEN. This came, if I may interject, because there was no research and development title in NACA. You will recall I described that our money came from three pots.

Mr. TEAGUE. Yes.

Dr. DRYDEN. So part of the money was in the old NACA appropriation, and part of it in the $80 million that Congress appropriated in the supplemental.

Now, this year we have a combined appropriation structure and the two are put together.

Mr. WOLF. I think what Mr. Karth is referring to, though——

Mr. KARTH. Yes.

Mr. WOLF. The breakdown of $1,728,000. How many employees are going to get that, I think—isn't that what you are after?

Dr. DRYDEN. On page 211 begins the breakdown of that figure.

Mr. SIEPERT. These are shown on pages 211 on through the next four or five pages, in which we give you a comparison by years and for each station, so that you can see the items that were done with this year's money and items that would be proposed next year.

Dr. DRYDEN. You will find on page 218 the same $1,728,000. It is a total of the items on the preceding pages.

Mr. SIEPERT. You will find this is the technique used for each of those figures.

I would like, if I may, Mr. Chairman, to make one specific comment—if there is no comment directly on seven.

Mr. TEAGUE. I want Dr. Dryden to define what you mentioned a minute ago—mach 13 ceramic jet.

Dr. DRYDEN. Well, this is an apparatus for reproducing for materials testing the high temperatures that occur on the front end of a ballistic missile nose cone as it reenters the atmosphere.

The jet works somewhat in this way: There is a sizable iron tank or pipe with insulated walls which contains a lot of ceramic pebbles. Ceramic means in this case zirconium pebbles. You have an oil

burner and you get this thing awfully hot. You burn the oil, which puts hot air through these pebbles. Then you shut the heat off and you have a tank of compressed air. You blow air up through this pebble bed and that heats it to a very high temperature. It comes out of the nozzle at the end. You put in a piece of material and see whether it burns up—melts, burns, or what happens to it.

Now, ceramic refers to these pebbles.

Mr. TEAGUE. Wait a minute. We haven't got to mach 13 yet. Does that mean it travels at that speed?

Dr. DRYDEN. Yes. The speed of the jet is 13 times the speed of sound at this very high temperature. I don't know—what is it, Milton?

Mr. AMES. I would have to guess.

Dr. DRYDEN. 13,000 feet per second?

Mr. AMES. Yes.

Dr. DRYDEN. Something of that order. So mach 13 refers to the speed. Ceramic refers to these pebbles that you first heat up with burning oil, and then you use it to heat the air up in this jet. It is just a shorthand name for a bed of pebbles.

Mr. BASS. What is the function of the pebbles?

Dr. DRYDEN. To store the heat. It is kind of like—you store the heat in the pebbles by burning oil through it. You can't use that—you want air as the working fluid when you test the materials. So you just heat this pebble bed up and get it very hot. Then you blow air through it. You heat the air.

Mr. BASS. I see.

Dr. DRYDEN. This kind of thing is used in the steel industry and other industries quite a lot. Where they heat up the tower and then pass the gases through it, preheating the air that is going to be used in the steel furnace, for example.

Mr. TEAGUE. Let us see. Do we have any other? That was close to my guess, Dr. Dryden.

Mr. SIEPERT. If there is no other question on the item——

Mr. TEAGUE. Let me ask you.

Mr. SIEPERT. Yes, sir.

Mr. TEAGUE. Mr. Yeager, or Dr. Sheldon—they are going to be doing the hard work on this thing—I would like to ask each one of them as we go along if you have questions.

Mr. YEAGER. I have two questions.

Mr. TEAGUE. Mr. Yeager.

Mr. YEAGER. On the NASA plant item. On page 207, you list a research contracts figure there of $8.2 million although that is not totaled in that particular group.

Mr. SIEPERT. This is an error in the pages. The correct figure is $5.2 million.

Mr. YEAGER. I was going to ask you why that differed from the figure on page 201.

Mr. SIEPERT. We didn't pick it up. Our system of cross-checks didn't catch it. It is correctly reflected in all the other pages.

Mr. WOLF. It is $5 million even.

Mr. SIEPERT. No. There are two errors on that, if I may. It is $5,200,000 in the last column, and it is $3 million in the second column.

Mr. BASS. Instead of $5.5.

Mr. SIEPERT. Yes, sir.

Mr. WOLF. $3 million even?

Mr. SIEPERT. $3 million even; yes, sir. And that would change this next goal to $4 million, in the third column.

Mr. TEAGUE. Mr. Wyatt, all the way through this—there is no reason for us to look at the 1959, except for comparison purposes.

Mr. WYATT. No, sir; only for comparison.

Mr. TEAGUE. In other words, what we are talking about is 1960, all the way through on every page.

Mr. WYATT. That is correct; yes, sir.

We have submitted the 1959 figure so you would have a basis for comparing the requested sums with what we have allocated this year.

Dr. DRYDEN. This year, of course, is not a completely satisfactory basis because we are in the process of transition from the old NACA.

Mr. TEAGUE. We understand, Dr. Dryden.

You are taking over these plants from defense, and defense has paid part of your budget?

Dr. DRYDEN. Yes, sir.

Mr. SIEPERT. Some of the figures in 1959 really represent an attempt to accelerate a program for only 9 months rather than for 12 months because we started in operation October 1 on this new mission.

Mr. WOLF. That is a good point.

Mr. TEAGUE. Mr. Yeager?

Mr. YEAGER. I have just one other question on this plant item.

Beginning on page 223, you have requirements for new scientific and research equipment. I wasn't quite able to correlate that with your equipment figure, of $5,610,000. Where does it come in, or are you coming to that?

Mr. SIEPERT. Mr. Ulmer. It is tied in with another figure earlier here.

Mr. ULMER. If you will look on page 222 you will find a breakdown of what we call new equipment. In the first column, which is headed "Scientific and Research Equipment," under the fiscal year 1960, at the bottom of the page, the sum of $2,776,700. This is the big bulk of the new equipment, and for that reason we gave a breakdown on the following pages to give you an idea of what types of items were included.

Mr. YEAGER. Thank you.

Mr. ULMER. New equipment is one part, then, of the total equipment item, the remainder being replacement equipment, and what we call recurring equipment—our normal annual needs for instrumentation.

Mr. YEAGER. That is all I had, Mr. Chairman.

Mr. TEAGUE. Mr. Bass, do you have any more questions?

Mr. BASS. No, I haven't.

Mr. TEAGUE. Mr. Karth?

Mr. KARTH. No.

Mr. TEAGUE. Mr. Wolf?

Mr. WOLF. No.

Mr. SIEPERT. If I may, then, shall we go to the next item, which is the support of the jet propulsion laboratory?

Mr. TEAGUE. Yes, sir.

Mr. SIEPERT. This is shown here as $8,156,000.

Mr. TEAGUE. What page is that on, now?

Mr. SIEPERT. The narrative is on page 226.

The jet propulsion laboratory is a Government-owned facility operated under contract by the California Institute of Technology. This is one of the country's outstanding laboratories, and was transferred to us by Executive order from Army cognizance prior to our getting into operation.

We financed this research and development operation from the R. & D. appropriation account.

The particular item of $8 million that is shown here represents only a part of the financial support of this laboratory. It is actually a lab with some $30 million in capital investment, and the supplemental bill which you already considered has a $9 million item to expand those facilities for its larger mission with us. It has a staff of about 2,400 people at the present time.

The particular item of $8 million that is shown here represents the function that we call supporting research in the jet propulsion laboratory.

Now, if we can visualize this a moment. We are talking about an organization that now is devoting about half of its effort to the completion of Army missile assignments, particularly the Sergeant. It is a hardware development job.

There is another part of the jet propulsion laboratory which operates two wind tunnels, and these wind tunnels were built expressly for Army and Air Force requirements, and are funded at the present time by the Department of Defense.

There is a third segment which is the supporting research program, and this is a group of scientists and engineers who are concerned with a number of investigations in various fields of, let us call it basic work, basic technology that will contribute to our knowledge of space vehicles.

This $8 million supports that hard core of basic work.

Now, in our operation of the jet propulsion laboratory we will add to this organization contracts for specific work on systems or vehicles that are of great interest to us. The money for those vehicles is not shown here. It is shown under the research and development program, under either the Vega program, which is a new space vehicle we are after, or it is under deep space probes, which is an area of specialized competence at the jet propulsion laboratory.

So I make this note to point out that at the present time the funding of the Jet Propulsion Laboratory includes not only the $8 million, but it actually includes at the present time $1.3 million for study of ways to probe deep space. It has $3 million to get started on the Vega program, which will be described elsewhere. And $2 million to develop an upper stage engine, a 6,000-pound engine, which will be used in the last stage of the Vega project.

So you see at the present time there is about $14½ million in 1959 money in that situation.

We anticipate that totally the Jet Propulsion Laboratory next fiscal year will have business there totaling about $48 million. And I am including——

Mr. TEAGUE. You said $14 million in the 1959 program?

Mr. SIEPERT. That is right, of our moneys.

Mr. TEAGUE. Of your money.

Mr. WYATT. Of NASA money.

Mr. SIEPERT. Of NASA money. We anticipate next fiscal year the Jet Propulsion Laboratory will have something like $48 million worth of business, and in that figure I am including the Army and the Air Force financing. Our own figures will be in the order of around $34 million.

Mr. WYATT. That is right.

Mr. TEAGUE. Mr. Wolf.

Mr. WOLF. How does a layman, a taxpayer, know that he is getting his money's worth out of this basic research?

Mr. TEAGUE. He doesn't.

Mr. WOLF. I know he doesn't. But is there some simple formula or something that we could hold in our hand?

Mr. WYATT. No, sir.

Mr. WOLF. This sounds like a ridiculous question, but this is being asked me all the time.

Mr. TEAGUE. Let me answer that question one way. Dr. Waterman just put out a report on the National Science Foundation, where he goes into detail about that. I am sure it is in your office, and you ought to read it. It makes it very——

Mr. WOLF. OK, Chief.

Mr. TEAGUE. Actually, he says over and over that one of the big problems we have in our country is justifying basic research, which you can't do.

Mr. WOLF. I realize that.

Mr. TEAGUE. You may get your money's worth and you may not. I think we have to have some faith in the men who are working on it. Of course, when these men get to the Appropriations Committee they are going to get some more critical questions. I am sure Dr. Dryden knows that.

Mr. SIEPERT. I suppose you might want a comment from Dr. Newell, from our headquarters staff.

Mr. WOLF. I wasn't attempting to embarrass anybody, but it is a basic question.

Dr. NEWELL. It is a basic question.

I would like to give you a couple of examples that might be useful to you. Many years ago, 50 or more years ago, a fellow named Roentgen was playing around in his laboratory with evacuated tubes, and he was trying to get some electrical discharges, and so on. Well, he didn't really know what he was looking for. He was just doing what he called basic research. But he discovered X-rays and it wasn't more than a year or two before they were put to use in medical research. And, of course, in the course of years now we use X-rays for examining structures of metal castings, and things of that sort, in all kinds of practical applications.

Now, if you think of yourself in this position many years ago, and think of yourself as asking Roentgen "Now, you get busy and develop something that is useful to medical research," I suspect he would have put those tubes away and you wouldn't have gotten X-rays which are so useful.

Now, another example, Lee DeForrest was playing around with evacuated tubes at the beginning of this century. He came up with the triode. He called it the audion tube at that time. But that is the basis now of all our electronics industry. You couldn't have gone to

him and instructed him to do something that would give us radios and televisions and things like that.

Mr. TEAGUE. Dr. Newell, isn't it also true that in our propulsion business someone dropped aluminum powder in some solid propellants and found out—they still don't know why—that it increased the power some considerable extent?

Dr. NEWELL. It is certainly true. You get much higher specific impulses from these inclusions in your propellants.

I would like to respectfully point out that your statement that sometimes you do get the payoff and sometimes you don't, isn't quite right. In the total of basic research you do in the long run get a payoff.

Mr. TEAGUE. Either a failure or a success.

Dr. NEWELL. Well, you get a payoff, a successful payoff in the total picture. It may be that this little piece over here didn't give you a payoff, but you had to have this piece to make the whole pattern.

Mr. TEAGUE. Yes, but you know it didn't pay off.

Dr. NEWELL. Yes, in advance you wouldn't know which one is going to pay off.

Mr. TEAGUE. And also you don't know, where something at the moment may not have meant too much, but later on it turns out to be a very important checker in the checkerboard.

Dr. NEWELL. This is quite correct.

Also time scales are important to keep in mind. Basic research really pays off in decades, not in years. So you can't ask when you start a basic research program that somebody report back to you next year what practical values you have gotten out of that. He may have an answer for you. But the fact that he doesn't have an answer won't mean that you aren't going to get your money's worth in the long run.

Mr. TEAGUE. Go ahead, Mr. Siepert.

Mr. WOLF. Thank you.

Mr. BASS. I have one question. I could ask it anywhere along here. But I would anticipate that one of the questions that we would be asked here: Is this enough money to support an adequate research and development program? How would you suggest——

Dr. DRYDEN. If I may answer that? This is enough money as we see the program at this moment. In all of our budget discussions, reviews, and talks with Congress, we have made it clear that if we think we need more we will be back.

The reason we can't be so precise is: You cannot tell exactly what everything you are going to run into costs. You can't get fixed price contracts on a completely new item.

Mr. TEAGUE. I think, Dr. Dryden, it might be pointed out, too, that the bill provides they may go up or down on certain items, but they won't go over the total.

Dr. DRYDEN. That is right.

Mr. BASS. Within specific limits.

Dr. DRYDEN. It gives us the flexibility.

Mr. SIEPERT. The answer to your question prompts me to emphasize one thing Dr. Dryden has just referred to. The accomplishment of most of these tasks in this research and development area will require our working with industry in areas where industry does not have cost experience. We will not be getting many of these things on a fixed price basis.

The budget before you represents very hard headed thinking on what these items—many of them as yet undesigned—will cost.

I emphasize the hard headed side of this, because if any of you have followed military hardware procurement items you may be familiar with the problem that always plagues the military, of what are known as overruns in costs. This is not poor planning, necessarily. This is because you ran into a technical obstacle that costs you money to overcome. We need to be prepared for the fact: We say this is the budget that we need, and if things are right we will do the job with this money unless we run into large overruns or anything else like that. There is no fat in this budget to keep this program on the road.

In other words, there is——

Mr. BASS. Yes.

Mr. SIEPERT. I should say this, that there is no contingency budgeting in this thing, in terms of a reserve for unanticipated problems.

Mr. TEAGUE. Right.

Mr. SIEPERT. So it is a hard rock budget for the committee to consider.

Mr. BASS. Thank you.

Mr. TEAGUE. Where did we quit?

Mr. WOLF. We are still at Jet Propulsion Laboratory, I guess.

Mr. SIEPERT. Unless there are other questions. I have nothing further to say on the Jet Propulsion Laboratory.

Mr. WYATT. We might call your attention for the record to the fact that the breakdown of the proposed expenditures at JPL for this share of the program are on pages 227 through 229.

Mr. SIEPERT. That is the supporting research.

Mr. WYATT. The supporting research which aggregates this $8,156,000.

Dr. SHELDON. Mr. Chairman.

Mr. TEAGUE. Dr. Sheldon.

Dr. SHELDON. If one did want to find the total NASA expenditure in JPL, is that something that can be derived from this book? You have told us approximately that it might be a question somebody would ask.

Mr. SIEPERT. No, it cannot. This is the reason I volunteered. But I think it would be helpful to the committee—if you would like, we will put in a table of proposed gross amounts that will be in the Jet Propulsion Laboratory.

Mr. TEAGUE. I think it would. Because that is just the kind of a question you can get.

(Material referred to follows:)

ESTIMATED FUND COMMITMENTS TO JET PROPULSION LABORATORY

The following table indicates the anticipated funding commitments to the Jet Propulsion Laboratory during fiscal years 1959 and 1960.

	1959	1960
NASA research and development	$14,756,500	$33,995,500
Army contracts	26,475,000	10,635,000
Air Force contracts	1,840,000	1,350,000
Total	43,071,500	45,930,500

The Army contracts indicated include funds in support of the Sergeant missile program which is funded on a calendar year basis.

In addition to the moneys indicated above, the Jet Propulsion Laboratory will be asked to handle the construction of tracking facilities at various locations around the world to the total sum of $6,050,000 in fiscal year 1959 and $1,350,000 in fiscal year 1960. In addition, funds totaling $9 million have been requested from the Congress in a supplemental 1959 appropriation bill for modernization and expansion of facilities at the Jet Propulsion Laboratory, Pasadena, Calif.

Mr. SIEPERT. All right.

Dr. SHELDON. Thank you, Mr. Chairman.

Mr. TEAGUE. All right. What is the next item? Research contracts?

Mr. SIEPERT. Research contracts.

Mr. WYATT. Yes. And to discuss the research contracts——

Mr. TEAGUE. Thank you, Mr. Siepert.

Mr. WYATT. I would like to have Mr. Milton Ames, Chief of the Aeronautical and Flight Mechanics Research Division.

Mr. AMES. Dr. Dryden and Dr. Newell, also.

Mr. TEAGUE. Does Ames Research——

Mr. WOLF. I was going to ask him that.

Mr. AMES. I don't know whether it has helped me or not.

Mr. WYATT. He is not related to the Dr. Ames for whom the Ames Laboratory was named.

Mr. WOLF. It was named after the State University at Ames, Iowa.

Mr. TEAGUE. That is a good point.

Mr. AMES. Gentlemen, the research contract part of the budget, in fiscal year 1960, is $5,200,000. In fiscal year 1959, the total sum was $4 million.

Dr. DRYDEN. It shows $3 million. The other million was again this problem of split budgets.

Mr. AMES. I was adding it up to compare to the total amount we had.

Dr. DRYDEN. On the table they have in front of them, they have that combination. I wanted to bring it out.

Mr. WOLF. Mr. Chairman.

Mr. TEAGUE. Mr. Wolf.

Mr. WOLF. What I am curious about is how the college or university is selected to get these contracts?

Mr. AMES. Well, sir——

Mr. WOLF. We have several in Iowa, you see.

Mr. AMES. Yes. We receive proposals from men, universities, and organizations that want to undertake research for us in this aeronautics and space area, under contract.

Mr. WOLF. Do you solicit these proposals on a blanket mailing proposition, or do you just hope they will come in?

Mr. AMES. It is well recognized among the universities that we are in the business of trying to complement our capability by contracting with the universities, to bring in a new approach, in the field where we do not have in-house competence.

Dr. DRYDEN. We have a special office with a staff of a few people who visit the universities.

Mr. WOLF. This is generally known?

Dr. DRYDEN. It is generally known throughout all the universities.

Mr. WYATT. If I may interject a point that will perhaps help clarify this? We not only use the universities for the very basic type of work discussed under this heading, but, of course, in the State University of Iowa we have Dr. Van Allen.

Mr. WOLF. Thank you.

Mr. WYATT. Whom we rely on very heavily for certain of our flight instruments and packages.

Now, in those cases we have a dual policy in which we not only solicit the scientific community at large to come to us with proposals, but we do go to people such as Dr. Van Allen with a request that he undertake a certain type of instrumentation.

Mr. TEAGUE. In other words, you are very happy to get a man with an idea from a university?

Mr. WYATT. We are.

Mr. TEAGUE. If you people get the idea, then you go to those you think are capable?

Mr. WYATT. Where we think the competence resides, yes.

Mr. TEAGUE. Right.

Mr. WYATT. It works both ways.

Mr. WOLF. I don't know if that is the complete answer you had in mind to give?

Mr. AMES. Yes, sir.

Mr. WOLF. Thank you.

Mr. TEAGUE. Mr. Ames, I hope you will comment a little bit on cosmological sciences, just in terms I can understand.

Mr. AMES. May I pass the ball on that to Dr. Newell?

Dr. NEWELL. All right. "Cosmological sciences" really is a fancy way of saying we are trying to understand what is the basic makeup of the universe. In this area, for example, the meaning of gravitation, the fundamental meaning of gravitation, is one of the items.

The general theory of relativity comes in here. Is it correct as Einstein stated it, or is it not correct? The meaning of energy. Where does it reside? When does it change into mass and when does mass change into energy? Those things come under the cosmological sciences.

And under the life sciences we mean the chemistry and physics of life—the fundamentals that one must know before one is able to do the engineering, for example, that must be done to put a man in space.

Mr. TEAGUE. Right.

Dr. NEWELL. To build him a system that will provide his food and his oxygen and the proper temperature and humidity, and so forth.

Mr. TEAGUE. Mr. Bass, any questions on that?

Mr. BASS. No. I thought that was very well stated, though. I am glad you asked.

Mr. WOLF. Well, I am glad that someone else is taking that field, that I don't have to get into the cosmological field.

Mr. BASS. I don't imagine you will find all the answers to this question in fiscal 1960.

Mr. WYATT. No, sir.

Mr. TEAGUE. Any other questions on the research contracts?

(No response.)

Mr. TEAGUE. All right, Mr. Ames.

The next is sounding rockets.

Mr. WYATT. Yes, sir. And to cover several fields here which are grouped together under the broad heading of scientific investigations

in space, I would like to ask Dr. Homer Newell, who is our Assistant Director for Space Science, to generally cover the next three areas.

Mr. TEAGUE. Mr. Gleason, something else before I forget it.

Mr. GLEASON. Yes, sir.

Mr. TEAGUE. I want a biography on each of the men that are before the committee.

Mr. GLEASON. Fine, sir.

Dr. NEWELL. Mr. Chairman, if I my comment on the objectives here.

This was written generally for the scientific community. A simple way of stating the objectives is simply to use rocket vehicles to explore the atmosphere and to perform experiments there.

Our task in the sounding rocket program is to extend the frontiers of knowledge. It is the basic research about which Mr. Wolf asked a question a short while ago.

The main need for funds here is to provide supporting research in universities, in NASA laboratories, in industry, and so forth, on the development of new techniques, new measuring instruments, and then to provide the hardware necessary to launch these instruments, and to use these techniques in the upper atmosphere. This in brief is what the sounding rocket program requires.

Mr. TEAGUE. All right.

Mr. WYATT. Mr. Teague, if I may interject something that may help clarify this and some subsequent sections? If this cup represents the earth, there are several ways we can explore space. One is we can send a rocket off that goes up a ways and falls back. Now, by definition, if it doesn't go more than 4,000 miles, or one earth radii out, we call this a sounding rocket.

Now, on the other hand, we may send rockets which go off into space, as did the successful Pioneer shot, and become a part of the solar system. This we call a deep space probe or a lunar probe, depending on its particular objective.

Then, of course, we may send objects off into space and have them just go around and around and fall back at some time in the future, depending upon the altitude.

Mr. TEAGUE. What is this?

Mr. WYATT. This we call a satellite.

Mr. TEAGUE. CASI (reading).

Mr. WYATT. Cislunar.

Mr. TEAGUE. Yes, cis.

Dr. NEWELL. "Cis" comes from the latin meaning "nearer to you." So cislunar means nearer to you than the moon.

Mr. TEAGUE. The moon?

Dr. NEWELL. Yes.

Mr. WYATT. Between us and the moon, that section.

Mr. TEAGUE. What about beyond the moon?

Mr. NEWELL. Then we call that interplanetary, between the planets. You could call it translunar if you wish.

Mr. WYATT. This is one of the areas where even the scientists are not wholly in understanding as to what each one of these terms specifically means. They are little shorthand phrases that creep into the jargon to try, in one word, to describe something.

Dr. NEWELL. Those who have studied Latin may remember Caesar's conquest in Cis-Alpine Gaul and Trans-Alpine Gaul. That means the part of Gaul that is nearer to Rome.

Mr. TEAGUE. How do you spell it?

Dr. NEWELL. C-i-s-A-l-p-i-n-e. "Nearer to Rome than the Alps," is what it means. This is where we got it from.

Mr. WOLF. That is wonderful.

Mr. TEAGUE. This is education we are getting this morning.

Dr. NEWELL. Under item 4—

Mr. TEAGUE. What page now?

Dr. NEWELL. This is page 233, still under sounding rockets.

The scientific and technical studies amount to $500,000 in 1960. These cover such things as recovery systems, for getting equipment and specimens back from rockets. This is different from the man in space recovery system. Specialized for sounding rockets. Or the design and, actually, invention, if I may use that word, of detectors, let's say, to measure solar radiation in the ultraviolet region rather than in the visual which we see on the ground. Or perhaps the development of a fast read-out system for reading out data quickly. From these sounding rockets we get a tremendous amount of data. We want to read it out quickly.

Under the next item, prototypes and operational hardware: Rocket vehicles. We need in our program about one hundred sounding rockets per year. This is about the level——

Mr. TEAGUE. You only have 50 in here, don't you?

Dr. NEWELL. That is 50 for 1959. The last statement——

Mr. TEAGUE. Yes.

Dr. NEWELL. In that sentence it says 1960 funds will provide about 100.

Mr. WYATT. I think you can see these are not expensive per unit.

Mr. TEAGUE. Right.

Mr. WYATT. They are relatively inexpensive.

Dr. NEWELL. Particularly when you compare them to satellites.

Mr. WOLF. Is this the proper place to ask this question, Mr. Chairman?

Mr. TEAGUE. Try it and see.

Mr. WOLF. On the recovery of the first and second stages, is there any research being done? I have been asking this question mostly because some of these rockets are very expensive.

Dr. NEWELL. Yes, sir.

Mr. WOLF. To recover them in a condition so that they can be reused?

Mr. WYATT. Sir, in the half of the R. & D. that you are not treating, and which another subcommittee is treating, there are items in here for fiscal 1960 for the study of booster recovery systems. There is some small amount of work going on in the country at the present time. We are asking through that subcommittee an appropriation element—we are asking, I believe, for about $1½ million to do some good hard studies, including wind tunnel tests and small-scale tests of actual recovery systems. We do consider this a very essential step, because as we go to the bigger and bigger boosters they are going to become much more expensive and it is very prudent to try to recover as much as possible for reuse.

Dr. NEWELL. And I might add that we have in the past many years been using this recovery technique on the payloads, which are expensive. And many payloads have been reflown a number of times.

To come to the next item, which is payloads, you will note that they cost about as much as the rockets themselves. So it is definitely worthwhile to recover them and reuse them.

The developmental sounding rockets, the $2 million item, is in here rather than in the large vehicle program because in the atmospheric research you have to fix up your rocket to fit your specific experiment. At the present time we are working on an inexpensive vehicle to carry payloads out to 4,000 miles. This will cost a lot less than any of the satellite vehicles which could be used. We could, if we wanted to, use satellite vehicles or space probe vehicles. But this would be an expensive way of doing the job that can be done much cheaper. Hence this item here.

On the next page, 234, under operations and technical services, this pays for the launching of the rockets and the field operations that are associated with them.

Launchings take place at places like Wallops Island in Virginia, at Fort Churchill in Canada, and sometimes from shipboard.

Mr. WOLF. How do you spell Wallops Island?

Dr. NEWELL. That is W-a-l-l-o-p-s.

We also launch these sometimes from San Nicholas Island off the coast of California. In the past we have done a lot of our work at White Sands in New Mexico.

Finally, under supplies, equipment, repairs and alterations, the moneys here are for such things as ground stations, telemetering trailers to get back the radio data from the sounding rockets, and in the next year and a half, for preparation of equipment, ground stations, and so forth, for a trip to Woomera, in Australia, where we wish to study the southern skies.

Mr. WOLF. May I ask on this again this question of how you arrive at who gets the contract?

Dr. NEWELL. In the case of operations and technical services, we have for a long time been working with the New Mexico College of Agriculture and Mechanic Arts because, for one thing, they were located right near White Sands where most of the work was going on, and for another thing, they were one of only a few colleges that wanted to do that sort of work.

It is based on competence and interest and nearness, proximity, to where they are being used.

Now, in the case of the New Mexico college, that last category no longer applies because they have been going with us to places like Fort Churchill, and so on.

In the case of building telemetering trailers and outfitting ships and so on, if it is outfitting the ship we generally go to the Navy yard that is near where the ship is going to be and we use them.

In the building of telemetering trailers, we generally let out bids, describing specifications for the trailer, what it must do and the kind of equipment that must go into it, and on a competitive basis choose the one who comes up with the best bid.

Mr. TEAGUE. Is that satisfactory?

Mr. WOLF. I just wanted that in the record because I am sure there will be some question on it.

Mr. TEAGUE. Scientific satellites.

Dr. NEWELL. Scientific satellites.

The objectives here can be very simply stated. To use satellites, artificial satellites of the Earth, to extend the frontiers of knowledge in space.

The program costs under item 4 are to cover the launching of satellites by means of Juno II vehicles. Those are the vehicles provided by the Army Ballistic Missile Agency and the jet propulsion laboratory. Also the use of Thor Delta vehicles. We also use Vanguard vehicles. However, those vehicles have been paid for out of the IGY program. Some of the supporting work, data reduction work, might be covered in here.

Mr. TEAGUE. Doctor, may I say, when I am asked why it was $1 million in 1959 and $3 million in 1960, that it is because you advanced your information and there are more things to find out.

Dr. NEWELL. It is. In 1959, we were picking up this program which had been underway under IGY auspices and other funding.

The scientific and technical studies again. Here as in the case of sounding rockets, are to provide the supporting research and thinking and devising ingenious ways of making measurements and so forth.

Mr. TEAGUE. Doctor, this sounding rocket: Is the payload in the sounding rocket budget, or is part of the payload in this?

Dr. NEWELL. There will be payload moneys here.

Mr. WYATT. Sir, this is only the budget for the satellites of the Earth—those which go around.

Mr. TEAGUE. Yes.

Dr. NEWELL. Yes.

Mr. WYATT. This is entirely a separate program category from sounding rockets.

Dr. NEWELL. I was merely pointing out that there is a comparable item here to support this activity.

Mr. TEAGUE. Right.

Dr. NEWELL. The next item: Prototypes and operational hardware: You will note in fiscal 1959 a considerably larger sum than in fiscal 1960.

Mr. WOLF. This is because we were picking up our program with vehicles available in the Department of Defense and could not rely on a NASA or national program to provide us with our vehicles.

Now, in another committee, this question of the national vehicle program is being reviewed. We will in the future be able to get into the vehicles that come out of that.

Mr. WYATT. I think I may clarify this a bit, sir.

In 1959, the first two items under prototypes in operational hardware, are for specific Juno II and Thor-Able vehicles. These we consider as much as any of these vehicles can be called, off-the-shelf items. In other words, they are obtained from standard production runs and they have to be modified to accommodate our payloads and certain items, but basically they are off-the-shelf items. And we included the funding costs under the satellite program as a part of the satellite program.

Now we get into 1960. We are going to continue with a few of the Juno II vehicles and we have carried a line item of $4 million for the Juno II's. However, we are switching the bulk of the scientific satellite program to this new vehicle called Thor Delta.

Now, I don't want to confuse you with a lot of technical terminology on the vehicles. The Thor Delta is similar to what we call the Thor Able. That is, it has the Thor IRBM booster first stage and has the upper stages that are the upper stages of the Vanguard vehicles. But the Delta differs from the Able principally in details of guidance and in certain of the mounting connections between the stages.

It does, however, represent an item in which there is some development money. It will be gone into in another one of your subcommittees. But where we are going to use vehicles which are not off-the-shelf items but do represent a development cost as well as a vehicle procurement cost, we have not shown the vehicle cost under scientific satellites but have founded it separately in a line item called Thor-Delta vehicles. And hence the vehicles that will be used for a good share of the 1960 scientific satellite program are being funded from another line item called simply Thor-Delta vehicles.

Mr. TEAGUE. Right.

Mr. WYATT. This explains why we do not have that item in this figure. The payload money is up in 1960 over 1959 because we are going to have more shots, hence we are buying more payloads, but we do not show in this item the vehicle.

Mr. TEAGUE. It is not an accurate comparison?

Mr. WYATT. No, sir, that is correct.

Dr. NEWELL. Still on page 236. That satellite payload item, the very last item, of $6 million.

Mr. TEAGUE. Yes, sir.

Dr. NEWELL. You may be asked or you may have a question of why these things are so expensive.

The point here is that a satellite payload has to be built in a small space, too small a space in many cases, out of a small allotment of payload weight.

It has to be built in such a way that it will survive vibrations and accelerations of launching and the heating of launching. Then it must continue to operate automatically all during its lifetime in orbit and sometimes to perform a number of command operations, commanded from the ground by radio.

So in order to make sure that the satellite is going to leave your hands, go into the vehicle and be launched, and come out of orbit in good operating condition, one must put this thing through extensive tests—vibration tests, vacuum tests, heating tests, lifetime tests, centrifuge tests, and so on.

This testing takes up a lot of time. It uses up a lot of people. Also, in building this satellite you have to build it out of special materials that often are very costly. You have to use miniaturization techniques, transistors and things like that. So you wind up with payloads that cost quite a bit.

Mr. BASS. This is $6,150,000. How many payloads does that cover?

Dr. NEWELL. An average cost for a satellite payload is about $1 million total.

Mr. BASS. So this——

Dr. NEWELL. So this is roughly half a dozen payloads.

Mr. TEAGUE. That is six payloads.

Mr. BASS. They are expensive.

Dr. NEWELL. That pays for actually three flight payloads, plus two payloads that you put through complete tests from what you expected in the launching environment and in orbit up to three or four or five times the severe environment you would expect.

Mr. TEAGUE. Doctor, does this represent all the payloads that you people will use for a year?

Dr. NEWELL. For the next year.

Dr. DRYDEN. Satellites.

Mr. TEAGUE. For satellites.

Dr. NEWELL. Yes.

Mr. SIEPERT. Satellites only.

Dr. NEWELL. Yes. The operations and technical services provide for our part of the launching of the satellites into orbit—the launching operations, data acquisition, the telemetering, the reduction of the data and its analysis after we get it back.

Mr. WYATT. Pardon me. There is one point I think should be clarified. These satellite payloads, as Dr. Newell implied, can be very, very complicated. In some cases they run over a year lead time in procuring them. Hence, it does not mean that this $6 million worth of satellite payloads are going to be fired in fiscal 1960. Some of them will be carried over and fired in fiscal 1961.

Mr. BASS. By the same token, some of the 1959——

Mr. WYATT. Some of the 1959 will be actually fired in 1960. It is this lead time proposition.

Mr. TEAGUE. If you people launch a satellite at Cape Canaveral, what cost do you pay or what part of the budget down there do you bear?

Dr. NEWELL. Of the field operations?

Mr. TEAGUE. Yes.

Mr. WYATT. Well, the exact sum depends upon the vehicle. But we pay what are known as range costs to them. This can run as high as perhaps half a million dollars a shot for a complex, large vehicle such as the Atlas. Between a quarter and a half million dollars a shot. We pay this to the Atlantic Missile Range as our share of their range costs.

Mr. TEAGUE. The one at Wallops Island is all yours, is it?

Dr. DRYDEN. That is for small vehicles.

Mr. WYATT. That is for small vehicles, with much less complicated launching and range procedure.

You see, when we fire from AMR, you tie up the range not only in the instrumentation of the firing——

Mr. TEAGUE. What do you mean, "AMR"?

Mr. WYATT. Atlantic Missile Range.

Mr. TEAGUE. That is Cape Canaveral?

Mr. WYATT. That is Cape Canaveral.

Dr. DRYDEN. I think you should say that in the firing of Thors and Jupiters, the same people do the firing that fire Thors and Jupiters, and we reimburse for the cost.

Mr. WYATT. Yes.

Dr. DRYDEN. In other words, this $6,850,000—a large part of that goes to ABMA and to the Ballistic Missile Division of the Air Force.

Mr. WYATT. Yes, so far as the basic vehicle is concerned, that is correct.

Dr. NEWELL. The next line item: Supplies, equipment, repairs, and alterations, applies to the things that we have to have to back up our operations. For example, we may have to modify a vacuum testing outfit or layout. As I mentioned, we have to give life tests on these objects. We have to heat them up to temperatures that we think they will experience in orbit and so on.

Well, it is that sort of thing that this covers.

Mr. TEAGUE. Dr. Dryden, any of these people that you know we are through with, if you want to let anybody go, you can.

Dr. NEWELL. I was going to say in the next two items—lunar probes, which are to study the moon in the vicinity of the moon, and deep space probes, on page 242.

Mr. TEAGUE. Yes.

Dr. NEWELL. Which are to investigate interplanetary space, beyond the moon and out to the planets, the breakdown is much the same. The needs are the same. It is for supporting research and development, for payloads, for operations and for special backup supplies.

Mr. WYATT. I do think the record should show in the case of deep space probes that we are not reducing our effort between fiscal year 1959 and 1960. This again represents a change in where we are allocating the cost of the vehicle.

Mr. TEAGUE. In budgeting. I think your Vanguard Division comes nearer having plain language than anything in the whole space budget.

Mr. WYATT. Yes sir, and that is phasing out. It is not in 1960.

Mr. TEAGUE. Are they finally going to give up on it, Dr. Dryden?

Dr. DRYDEN. There are two vehicles to be fired and then we will complete it.

Mr. TEAGUE. You had a completely new group of scientists who studied the thing, and still——

Dr. DRYDEN. We had one success since that study.

Mr. TEAGUE. All right.

Mr. WYATT. If we could move now, in the interest of time, to the next two categories, meteorology and communications, which are what we call applied satellite systems. I would like to ask Mr. Edgar Cortright, who is the Chief of Programs in our Advanced Technology Directorate, to discuss these two items.

Mr. CORTRIGHT. I think I can make this quite short.

Basically in the field of meteorology, we are trying to develop vehicles which will lead to more advanced vehicles, which in turn will fit into an operating system, which will serve the Weather Bureau and the armed services primarily.

The situation is this: We have funded two types of vehicles in the Vanguard program in 1959 and pre-1959 money. The major cost generators at the moment are a project known as Tiros, which was transferred to NASA from the Department of Defense this past Monday.

To complete, the funds in 1960 cover the completion of this project and a second launching of the same vehicle, which we have scheduled into our program.

In addition, however, I will say the majority of the $10.8 million will go toward the development of the follow-on meteorological satellite which comes after Tiros.

If we needed round numbers here, I would say out of that $10.8 million, about $8 million of it will go into the follow-on program and about $2.8 million will finish up Tiros in the followup—or rather Tiros and the second firing of Tiros.

Mr. TEAGUE. When do you think they will fire Tiros?

Mr. CORTRIGHT. There will be a firing, we hope, by January.

Mr. TEAGUE. How big a vehicle is that?

Mr. CORTRIGHT. It is a 270-pound vehicle, about 42 inches in diameter. It contains considerable equipment in the way of television cameras and infrared detection equipment.

Mr. TEAGUE. That is the payload, 270 pounds?

Mr. CORTRIGHT. Yes.

Mr. TEAGUE. The vehicle itself: What puts it up there?

Mr. CORTRIGHT. It uses a Thor-derived booster, actually a Thor Able, too.

Mr. TEAGUE. So you fire from Cape Canaveral?

Mr. CORTRIGHT. Yes. And the second firing of the Tiros will be nearly identical. The follow-on vehicle, which will consume the majority of these funds, will be placed into orbit with a Vega, and the payload will weigh in the neighborhood of 3,000 pounds.

Mr. TEAGUE. Is that Vega?

Mr. CORTRIGHT. V-e-g-a.

Mr. TEAGUE. That is merely the name of the project?

Mr. CORTRIGHT. Of a booster.

Mr. WYATT. It is a booster based upon the Atlas, with some upper stages that the Atlas does not have.

Mr. CORTRIGHT. We haven't named the meteorological project as yet.

Mr. WYATT. Vega is the vehicle name.

Mr. CORTRIGHT. Unless you care to ask questions or want me to go into more detail, I will go on to communication satellites.

Mr. TEAGUE. Yes.

Mr. CORTRIGHT. $4.7 million in fiscal year 1960.

Mr. WOLF. Might I ask if it would be possible to put a little pleasant-worded idea of why meteorology—the economics of meteorology—how this can apply to the folks back here, that sort of thing.

Mr. TEAGUE. In our report.

Mr. WOLF. Yes, for our report. This is something I think we can help them understand and I think this might help them to absorb some of the more esoteric aspects.

Mr. CORTRIGHT. I might say it is very difficult to arrive at a number in dollars which will be derived as a benefit from improved meteorology. But it runs in the billions, low billions, according to the Weather Bureau.

Mr. WOLF. I am sure——

Mr. TEAGUE. I flew into Dallas last Saturday night at 11:30 when there were three or four little tornados playing around, and I will tell you before I got on the ground I was wishing the day would come when that weather could be controlled.

Mr. CORTRIGHT. In the field of communication satellites, I went into it at some length as to the need for these vehicles. They are very real.

It really appears as if the communication satellites is the best answer to the big jam-up in world communications which we expect. There are two types of major interests to us, the reflective type satellite and the active repeater. The majority of this $4.7 million will go to support experiments which are hundred-foot inflatable spheres, used as reflective satellites.

A small portion of that money will go to study more advanced systems and systems utilizing active repeaters.

Now this work will be coordinated closely with the Department of Defense project on active repeaters. We merely want to insure that the equipment developed will be well suited for civilian needs.

Mr. BASS. A question. When do you hope to put up one of these big, 100-foot diameter reflective shots?

Mr. CORTRIGHT. November.

Mr. BASS. That will be a very spectacular thing, won't it?

Mr. CORTRIGHT. Well, if we bounce signals from the balloon——

Mr. WYATT. You were talking visibly?

Mr. BASS. Visibly, yes.

Mr. CORTRIGHT. Well, I think more exciting would be the receipt of signals across the country, by bouncing them off the balloon. That is what we are attempting to do. It will be quite visible, though.

Mr. BASS. How high would this be, roughly?

Mr. CORTRIGHT. Approximately 900 to 1,000 miles.

Mr. WOLF. Not visible with the naked eye?

Mr. CORTRIGHT. Yes, with the naked eye. When the sun is in the right position.

Mr. WYATT. Sunset or sunrise?

Mr. BASS. When we saw sputnik, as I did, that was much smaller, of course, than 100 feet.

Mr. CORTRIGHT. Yes.

Mr. BASS. This is maybe 15 or 20 times bigger than sputnik.

Mr. WYATT. Of course, it is at a higher altitude. But it should be very visible.

Mr. TEAGUE. Yes, sir.

Mr. WYATT. May I also get into the record that the sums for communications and meteorology do not include the cost of the vehicles about which they will be launched. These are the costs of the payload side.

Mr. CORTRIGHT. And ground equipment.

Mr. WYATT. And ground equipment for the program. But the vehicles are being funded from the advanced vehicle funding.

Mr. TEAGUE. Now, our big one.

Mr. WYATT. Yes, sir.

I would like to ask Mr. George Low who is chief of our manned space flight programs, to discuss the manned space flight.

Mr. LOW. I think I can make this a fairly short discussion also.

I described the program and our plans to the full committee the other day.

I would like to point out for fiscal year 1960 we are asking for $70 million for this program. A good share of that, almost $50 million, will go into actual hardware items; $2 million of that into the satellites themselves—the capsules which are under contract now with McDonnell Aircraft Co., and $27.7 million for the booster vehicles.

As I mentioned the other day, there is a large number of booster vehicles involved coming in the logical buildup of capability.

We are starting out with a small solid rocket booster. We are then going to fly capsules on the Redstone and Jupiter boosters and the Atlas.

Mr. BASS. This is known as Project Mercury.

Mr. TEAGUE. Dr. Dryden, what about this question about the Army?

Dr. DRYDEN. About the Army. Well——

Mr. TEAGUE. You don't need to answer.

Mr. DRYDEN. I want to tell you about this. There was an Army doctor on the group that fixed the specifications.

Mr. TEAGUE. Yes, I know that.

Dr. DRYDEN. There were no Army names originally submitted——

Mr. TEAGUE. Doctor, you don't have an Army man that has had this flight experience?

Dr. DRYDEN. Well, we asked the Army to give us some dossiers or files on people that they thought might be considered. They did produce six. They were not qualified and were not put through the series of tests.

Mr. TEAGUE. I was jesting, Dr. Dryden. I wasn't concerned at all about that. Mr. Low, now the majority of this is centralized at Langley?

Mr. LOW. That is correct. But the funds, the majority of the funds, of course, will go to contractors. The capsule money, as I mentioned, goes to McDonnel Aircraft Corp.

Mr. TEAGUE. Nobody has ever made a capsule. In a few words, why did you select this particular company?

Mr. LOW. We had an industrywide competition.

Mr. TEAGUE. You gave them specifications of what you wanted.

Mr. LOW. We gave them specifications of what we wanted. Based on these specifications, 12 companies submitted bids. These bids were evaluated by both the scientific or technical committee and by a management committee that looked into the costs and the past experience of the companies, and so forth. These two committees then reported to a source selection board and this board in turn made a recommendation to our administrator, Dr. Glennan, to select one of the companies.

Mr. TEAGUE. Right.

Dr. DRYDEN. This came out first in the competition.

Mr. WYATT. Yes.

Mr. WOLF. I would like to see something put into our report on the psychologic aspect of getting a man in space first—the psychologic warfare angle, very definitely. I think we need a strong statement here, because we are talking now about $70 million. There are a good many people in this country who still think this is all foolishness. But they will understand psychologic warfare, and there might be someone on the floor that will bring this question up, as to why. I would like to see if we could have that.

Mr. LOW. I think we should recognize, however, that we may not be first, but even if we were not first that this is an important step and perhaps the only first step in our long-range manned space flight program. This is going to be a continuing program that leads to space stations, to interplanetary flight stations.

Mr. TEAGUE. Possibly we are a lot more interested in an individual and his life than other countries. We will be a lot more convinced of his return, before we send him up, than some other country.

Mr. LOW. Very definitely.

Mr. WYATT. That is the primary consideration in our program.

Mr. TEAGUE. Dr. Sheldon.

Dr. SHELDON. I was just going to mention, Mr. Chairman, that the people at NASA are quite aware that there has been a lot of sniping from the sidelines over the choice of McDonnell Aircraft. And members of our committee should be well armed with that explanation and justification for that selection.

I am not questioning whether it was the right one, but it is something that might very well come up later.

Mr. TEAGUE. I think, Mr. Low, you might give us something about the specifications that were set up for these companies, in the competition. I understand this is a common practice throughout the Defense Department. If they want a particular missile, they set out the specifications, and they have a contest between companies.

Mr. LOW. That is correct.

Mr. TEAGUE. Then they go through each one and decide which one submits the best proposal.

Dr. DRYDEN. Mr. Chairman, we will prepare two statements, on "Why the man in space," and, second, the outline of the contractor selection procedure.

(Material referred to follows:)

URGENCY OF PROJECT MERCURY

One of the most significant milestones in the history of space flight will be the first successful launching, flight, and recovery of a man in space. The event will be of such importance that it cannot fail to earn worldwide acclaim for the technical skill of the nation first accomplishing the difficult task.

Project Mercury, the current manned space flight program of the NASA, represents this Nation's effort to place man in space. The project was conceived and is being carried out in a manner that will attempt to achieve the earliest possible space flight by man. It will use developed booster systems through all phases of the program. The space capsule, the actual flight vehicle, is based upon design principles that require no major technological breakthroughs for successful accomplishment.

Even though we in the United States apply our greatest efforts to this problem we must recognize that we may lose the psychological battle to be first. We cannot place prestige above life. A fundamental concept of Project Mercury is that the safe return of the astronaut must be insured. Other nations having less regard for human life may shortcut the development procedures that we think essential and may thereby accomplish manned space flight before we do.

Although we in the United States have no certain knowledge of the desires and intentions of other countries to be the first to achieve manned space flight, we cannot relax our own efforts in the hope that others will do likewise. To do so and to be wrong would insure a certain psychological defeat for the United States in the eyes of the world.

APRIL 28, 1959.

NASA PROCEDURE USED IN THE SELECTION OF A CONTRACTOR FOR THE PROJECT MERCURY CAPSULE

1. Chronologically the following steps were taken in order to select a capsule contractor for Project Mercury:

(*a*) On October 23, 1958, preliminary specifications prepared by NASA were mailed to prospective bidders. These specifications outlined the technical concepts and, in addition, presented suggested methods of analysis and construction.

(*b*) A bidders' conference was held at Langley Field, Va., on November 7, 1958. Thirty-eight firms were represented at this conference. The specifications were reviewed and further technical details were presented.

(*c*) On November 17, 1958, final copies of NASA specifications, S–6, were mailed to 20 firms who had indicated by telegram that they desired to be considered as bidders.

(*d*) Twelve companies submitted final proposals by December 11, 1958, the deadline for submission of such proposals. These companies were:

1. Avco, Research & Development Division.
2. Chance Vaught.
3. Convair, Astronautics.
4. Douglas Aircraft, Inc.
5. Grumman Aircraft Corp.
6. Lockheed Aircraft Corp.
7. Martin Co., Denver (with RCA, Astro-Electronics Products Division).
8. McDonnell Aircraft Corp.
9. North American Aviation, Inc., Los Angeles (with General Electric MSVD).
10. Northrop Aircraft Corp.
11. Republic Aviation Corp.
12. Winzen Research Laboratories.

2. The evaluation of the proposals submitted by the competing companies for this contract was carried out with great thoroughness and involved a great many man-hours on the part of our top engineers. The capsule contractor was selected only after a detailed technical assessment, and management, cost and production assessment of all of the proposals. Eleven teams, with a total membership of 31 men, evaluated specific technical areas. These teams reported to a six-man technical assessment committee. Concurrently, the management, cost, and production proposals were evaluated by a seven-man committee, and proposals were rated on six separate factors. The technical assessment committee was not informed of the contents of the management and cost proposals. The two assessment committees made separate presentations to a source selection board.

3. After careful evaluation of the technical and administrative factors, the source selection board submitted its findings to the Administrator, NASA, with a statement that McDonnell Aircraft Corp. had scored the highest combined rating. On the basis of all the findings presented to him, the Administrator awarded the contract to the McDonnell Aircraft Corp.

Mr. TEAGUE. Do you have questions?

Mr. BASS. No.

Mr. TEAGUE. All right, sir.

Mr. WYATT. Again, for your support, in case it comes up, we have included the cost of boosters in here, because these are essentially what we would call off-the-shelf type boosters. They are not development items. They are the IRBM and ICBM items in production.

Mr. TEAGUE. In production?

Mr. WYATT. Yes.

Mr. TEAGUE. All right. Space rendezvous.

Mr. WYATT. The space rendezvous techniques I will address myself to.

If we look down the road from the Project Mercury—there will be an end use to man in space, and it is quite likely that we will get into such things as space platforms or space orbiting laboratories which we will want to leave up for an extended period of time, which we must then reman from time to time—that is, change crews and take up supplies, and this sort of thing.

The problems of making a point-to-point contact in space are very, very great, and there are a number of technological problems that have to be solved in the guidance to get the objects into the precise orbits that you want. That is, to get the first one into an orbit that you can be

sure of, and the second one, of course, to make contact with that orbit, and to make course corrections if you do not get into a perfect orbit. All the matters of guidance, of the power required to make these corrections, of the navigational techniques you use to close in and know where you are, and all—there are a number of fundamental areas here that need to be studied. And we are requesting in fiscal 1960 the sum of $3 million to conduct experimental studies—experimental and theoretical studies—in this area of these many problems that are associated with rendezvousing in space.

This is to give us a jump on the problem when we get around actually to building such vehicles.

Mr. TEAGUE. Any questions?

Mr. WOLF. I would like to go back to man in space. While I agree with you wholeheartedly that we are going to be more concerned with the human life and the human value than the Russians, we still want to be pretty well forearmed on it if we are not going to be first. And you also suggested the fact that we probably won't be first. Why?

Mr. WYATT. Mr. Wolf, may we say this: This program is being laid on with all possible speed and urgency. The selection of the particular kind of capsule had this in mind. It is something that represents the highest new development, with no breakthroughs, that it is possible to conceive of, to put a man in space. This is one of the reasons we selected this particular configuration.

We are proceeding in the program as rapidly as possible. We are going to get the man into space as soon as we can get him into space, with the assurance that he gets in and out completely, that he can be recovered.

Now, we do not really know at what rate other countries are working on this problem of putting a man into space. We simply have to proceed, I think, on the assumption that certainly booster capability exists, and that undoubtedly a desire exists on the part of other countries also to be the first into space.

We have no knowledge that they will beat us. We are setting our own timetable at the fastest possible timetable that we think this country can accomplish. We hope that we will be first. Realistically, I think that we would kid ourselves if we thought that other countries were not interested in this same problem and might not be trying to——

Dr. DRYDEN. The morning paper carries a quotation from the Russians, I don't know with what authenticity, stating that they hope to do it within 2 to 10 years. Now, 2 years is roughly, of course, the timetable that we are working on.

Mr. TEAGUE. Of course you also don't know how many times they tried and failed. The only time we will ever know is when they succeed.

Mr. WYATT. That is correct.

Mr. WOLF. More money won't help you get the equipment. This is something we want to be able to state.

Mr. WYATT. No, sir. At this time, as we conceive the program, this money should suffice.

But, again, the reservation that Dr. Dryden has pointed out. If we find it will not suffice, we will be back, most assuredly.

Dr. DRYDEN. We are assuming we will get the money. You already authorized the supplemental, the $20 million there from the Appropriations Committee, as well as the money we have here.

Mr. WYATT. Yes, sir.

You may rest assured, Mr. Wolf, that if we are not the first to put a man into space, it will not be because we have dragged our heels in the conduct of the program.

Mr. WOLF. That is the statement.

Mr. TEAGUE. We are through as far as the hearing is concerned.

(Whereupon, at 12:25 p.m., the subcommittee adjourned.)

41011—59——18

1960 NASA AUTHORIZATION

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON INTERNATIONAL COOPERATION AND SECURITY (SUBCOMMITTEE No. 3),
Washington, D.C., Friday, April 24, 1959.

The subcommitttee met, pursuant to notice, at 3 p.m., in room 304, Old House Office Building, Hon. Erwin Mitchell (member of the subcommittee) presiding.

Mr. MITCHELL. The subcommittee will be in order.

Dr. Dryden, we are most happy to have you with us this afternoon, together with your associates. I would appreciate it if you would identify yourself and them for the record.

Dr. DRYDEN. I will. I am Hugh Dryden, the Deputy Administrator. I have with me, Mr. Ulmer, the budget officer, and Mr. Vaccarro, who will be the business manager of the Beltsville Center.

We are prepared to go over this in any way you like; either proceed with some general background, or proceed directly to questions.

Mr. MITCHELL. I think, first, Doctor, that Mr. King does have a series of questions which will be in the nature of background, that he would like to ask of you and your associates.

Dr. DRYDEN. He has discussed them with Mr. Ulmer, and I think I will let Mr. Ulmer answer them, since you have had a little prior discussion.

Mr. KING. Could I proceed, Mr. Chairman?

Mr. MITCHELL. Proceed.

Mr. KING. Mr. Ulmer, you have kindly discussed with me for a moment or two the general structure of this proposed budget. I wonder if you could restate what you told me for the record, indicating broadly how the proposed budget is divided into three broad classifications and what the rationale behind that is for dividing it into those three classifications, and in general what those three classifications cover.

Mr. ULMER. Yes, Mr. King. The three appropriations titles which make up the total NASA budget consist of salaries and expenses, commonly referred to as S. & E.; research and development, which we call R. & D.; and construction and equipment, which we call C. & E.

The S. & E. appropriation covers the salaries of all NASA employees, regardless of where they are located or what type of work they are doing.

It was the intent of Congress from the legislative history which supports the enactment of the NASA Act, that insofar as possible all normal annual expenses of the NASA be provided on a single-year basis. That is, the money becoming available at the beginning of a fiscal year and expiring for obligation at the end of that fiscal year.

This, then, led to the establishment of the S. & E. appropriation, which as I mentioned covers the salaries of all employees. The other expenses are travel expenses, transportation, communications, rents, and utilities, printing, security investigations, Federal life insurance, taxes and assessments, awards, and contributions to the retirement fund.

The research and development appropriation covers the bulk of the budget, about $333 million of a total of $485 million, and this is a no-year appropriation.

It provides money for all of the contractual services of the agency, the major part of which is required to support the development of new space flight vehicles.

As a matter of administrative simplicity many items of procurement required in running our laboratories—many big equipment items and many of the big supply contracts—are similar to the contracts that we let under the R. & D. item.

So for purposes of simplicity we have lumped all of the items for supply and equipment required in running our laboratories in this same R. & D. appropriation.

This simplifies our procurement procedures—I would like to give you an example. If a man is buying a series of rockets for use in basic research at one of our laboratories, he would like to write a contract for, say, $80,000 or $100,000 worth of rockets. Some of those rockets might be used to support our in-house effort. Some might also be used in support of a research and development contract.

To eliminate the need for that man having to decide at the time he obligates the money whether the rocket is going to be used in the in-house effort or to support the contractual effort, we have decided that all supply procurements would be funded under the research and development appropriation.

Now, the third item, namely, construction and equipment, covers the procurement and the contracting for all major facilities, that is all capital improvements of the agency, whose estimated cost exceeds $250,000.

This, again, is the requirement of the basic NASA Act which requires specific authorization for all those items.

So any single item whose estimated cost exceeds $250,000 and which results in a capital improvement is construction and equipment.

That generally is the background behind the three appropriations, Mr. King.

Mr. KING. There is no overlapping, then?

Mr. ULMER. No, sir, there is no overlapping.

Mr. KING. So that the salaries and expenses appearing in the first category would include all salaries?

Mr. ULMER. All salaries.

Mr. KING. And annual operating expenses?

Mr. ULMER. Right.

Mr. KING. Even though they might relate to R. & D. or construction?

Mr. ULMER. Or C. & E., that is right.

Mr. KING. Now, roughly what proportion of the total is represented by each of these three?

Mr. ULMER. $94 million, approximately 20 percent of the total budget, is for salaries and expenses. $333 million of the $485 million is R. & D.; that is the major portion of the budget. And $57.8 million is for construction and equipment, capital improvements.

Mr. King, if I could refer you for a moment to the chart on page 3. I have put those same figures in a pie chart that perhaps will give you a better picture of the distribution.

Mr. KING. Yes.

One other question. On the salaries and expenses.

Mr. ULMER. Yes?

Mr. KING. Now, is that broken down according to geographical coverage in your budget?

Mr. ULMER. It is, sir. It is broken two ways. The geographical coverage you will find on page 5 of the budget, starting with the requirements for NASA headquarters.

Mr. KING. Yes.

Mr. ULMER. The three major research centers at Langley Field, Va., Moffett Field, Calif., and Cleveland, Ohio.

Mr. KING. Yes.

Mr. ULMER. The high-speed flight station in California. The space project center at Beltsville; the pilotless aircraft station at Wallops Island; the Patrick office; the Western coordination office; and the Wright-Patterson liaison office.

Dr. DRYDEN. You may not be familiar with all the locations. The headquarters is here in Washington. Most of the people are in two buildings at 1512 and 1520 H Street NW.

Mr. MITCHELL. If I may interrupt you——

Dr. DRYDEN. Yes.

Mr. MITCHELL. I think you are going right into something that I think we should have for the record.

Dr. DRYDEN. Yes.

Mr. MITCHELL. And that is beginning with NASA headquarters. If you would identify each of these locations—the installations, and give a brief description of just what phase of NASA work is carried on there, it would be invaluable as far as the record is concerned.

Dr. DRYDEN. Yes. It would take a very short time to run this down. We have some pictures of some of the installations.

Mr. MITCHELL. Start, if you will, with just a brief word description of what is done right here at headquarters in Washington.

Dr. DRYDEN. Yes, sir.

In the Washington headquarters, of course, you have the usual people in a headquarters. They are the people who manage the operations primarily.

You start with the office of the Administrator and the Deputy. The major units here are the legal staff, which includes a patent section, the public information office, the congressional relations office, and the office of program planning and evaluation.

Now, these groups in the Administrator's Office.

Now, below this, there are three——

Mr. KING. Pardon me. How many are in this central office?

Mr. ULMER. We had 371 on duty April 15, Mr. King.

Dr. DRYDEN. 486 is the total requested for 1960.

Mr. MITCHELL. Right at that point, Doctor, we might—I note a change, an increase in headquarters of some 150.

Dr. DRYDEN. From 336 at the end of 1959 to 486 in 1960, an increase of 150.

Now, a large part of the increase in the headquarters staff comes from requirements in the act.

I mentioned the patents, for example. There is a rather complex patent provision. There is an inventions and contributions board set up to evaluate ideas submitted by people from outside.

In the public relations office in NACA, we had two or three people. As you know, the space business is in the public eye. We have had to take care of relations with the press when we have firings. That office has expanded.

We can give you some of the numbers.

Mr. ULMER. We have a complete breakdown, Mr. King, that we would be glad to insert in the record.

Dr. DRYDEN. We will put it in the record if you would like.

Mr. MITCHELL. Without objection, then, it will be filed and made part of the record.

(The document referred to is as follows:)

NASA headquarters complement

Division	Scientific and technical			Scientific and technical aides			Administrative			Secretarial and clerical			Trades, crafts, and laborers			Total			
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	X	A	B	C
Office of the Administrator	2	2	2				7	8	8	6	8	8				10	15	18	18
National Aeronautics and Space Council								1	1		1	1						2	2
Civilian-Military Liaison Committee								1	1		1	1						2	2
Inventions and Contributions Board							1	1	1	1	1	1					2	2	2
Assistant Administrator for Congressional Relations							4	5	5		1	1					4	6	6
Office of Program Planning and Evaluation	3	5	5				1	2	3	1	3	3					5	10	11
General Counsel							15	17	18	8	11	11				4	23	28	29
Office of Public Information							14	16	17	8	11	12				8	22	27	29
Office of International Programs							1	2	3	1	3	3					2	5	6
Total, Office of the Administrator	5	7	7				43	53	57	25	40	41				22	73	100	105
Office of Business Administration							2	2	2	2	3	3				1	4	5	5
Staff assistants							5	8	9	3	6	6				3	8	14	15
Budget and fiscal							11	14	14	11	12	12				17	22	26	26
Personnel							11	12	12	6	7	7				13	17	19	19
Technical information				1	1	1	10	12	13	13	15	16				32	24	28	30
Audit							7	8	8	2	3	3				3	9	11	11
Procurement							12	21	21	6	10	10				11	18	31	31
Security							8	9	9	7	7	7				8	15	16	16
Administrative services				1	1	1	10	13	14	20	23	24	9	10	10	11	40	47	49
Total, Office of Business Administration				2	2	2	76	99	102	70	86	88	9	10	10	99	157	197	202
Office of Aeronautical and Space Research	1	2	2							2	2	2				5	3	4	4
Assistants	5	6	6				1	1	1	4	5	5				6	10	12	12
Aeronautical and flight mechanics	9	9	9				1	1	1	4	4	5				13	14	14	15
Powerplants	7	8	8							5	6	6				12	12	14	14
Structures and materials and aircraft operating problems	9	10	11							7	7	8				12	16	17	19
Office of Research Grants and Contracts	4	4	4	1	1	1				3	6	6				7	8	11	11
Total, Office of Aeronautical and Space Research	35	39	40	1	1	1	2	2	2	25	30	32				55	63	72	75

See note at end of table.

NASA headquarters complement—Continued

Division	Scientific and technical			Scientific and technical aides			Administrative			Secretarial and clerical			Trades, crafts, and laborers			Total			
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	X	A	B	C
Office of Space Flight Development	1	2	2							1	2	2				4	2	4	4
Assistants	1	2	2				1	2	2	1	1	2					3	5	6
Advanced technology	10	12	13							4	6	6					14	18	19
Propulsion	9	17	18							5	9	9					14	26	27
Space science	6	14	15				1	1	1	3	8	8					10	23	24
Space flight operations		11	12					1	1		6	6						18	19
Program coordination		2	2					1	1		2	2						5	5
Total, Office of Space Flight Development	27	60	64				2	5	5	14	34	35				4	43	99	104
Total, NASA headquarters	67	106	111	3	3	3	123	159	166	134	190	196	9	10	10	180	336	468	486

NOTE.—Col. X, actual employment on Sept. 30, 1958; col. A, original authorized end of fiscal year 1959 staff; col. B, current authorized end of fiscal year 1959 staff; col. C, proposed end of fiscal year 1960 staff.

Dr. DRYDEN. Just to tell you what is there: There is an office of business administration, which has groups dealing with budget and fiscal, personnel, technical information, audit, procurement, security and administrative services.

Now, these are essentially policy groups. For example, the security office is a relatively small office. There are a total of 15 people in headquarters. They do the security examinations of headquarters people, but their main function is security policy for the Agency, NASA relations with the FBI, the military security groups, etc.

Mr. MITCHELL. Doctor, if I may, right at that point, I notice the amount for security investigations in the fiscal year 1960——

Dr. DRYDEN. Yes.

Mr. MITCHELL. The budget has almost been doubled, from $180,000 to $350,000.

Dr. DRYDEN. We have to take care of not only investigations of our own people, but we also have to take care of security investigations at contractors.

Now, we are making arrangements to do this.

Mr. MITCHELL. Who are these people that make these investigations, Doctor?

Dr. DRYDEN. Well, on the people—most of the investigations are made by the Civil Service Commission. This is a reimbursement to the Civil Service Commission.

Mr. ULMER. We pay them on a case basis, Mr. Mitchell, and this estimate has been worked out as a rather careful estimate of the turnover we expect in our staff and of the new people coming in.

Mr. MITCHELL. You actually have no people on the payroll of NASA who are designated to conduct security investigations?

Dr. DRYDEN. No security investigation is made by us.

Mr. ULMER. We have the Security Division, though, that monitors this work and is responsible for internal Agency security.

Mr. MITCHELL. But it is strictly an administrative part of the office?

Mr. ULMER. Correct.

Mr. SIEPERT. Mr. Mitchell, it has one other function. My name is Siepert, Director of Business Administration.

When the Civil Service Commission completes these—this is the door-to-door investigation of background—they do not evaluate the case.

You see, this is a responsibility of the program head, that is our Agency, to determine whether the particular individual is suitable to handle classified information.

That evaluative job of that record, the pulling of all those sources together, is done by our security staff. They make a recommendation which is then reviewed by Dr. Dryden and Dr. Glennan and a decision is made.

Just as in the case of the FBI, you know. Mr. Hoover has always said, "We do not evaluate the case. We have the program agency handle that."

Mr. MITCHELL. Who is head of that department?

Mr. SIEPERT. Mr. Robert Bell. He is our Director of Security.

Dr. DRYDEN. His background was as an FBI investigator.

Mr. MITCHELL. I see.

Dr. DRYDEN. To continue with the headquarters office, there are two program groups. One, we call the Office of Aeronautical and Space Research, which essentially is the group that oversees the operation, that is, the in-house operations at the research centers.

This is broken down into subject areas. There is a group dealing with powerplants, a group dealing with structures, a group dealing with aeronautical and flight mechanics, and so forth.

The people within these groups have the responsibility of detailed policymaking and supervision programs in these areas at the centers, and coordination with the military and with the Science Foundation. In other words, this is a headquarters staff.

The Office of Space Flight Development, similarly, is concerned with the bulk of this $333 million, the contracting of this money, that is overseeing the contracting of this money, in the technical sense.

The business office handles the business management of the agency.

The General Counsel handles the legal requirements of contracts, and so on.

On the technical side, there are people in the Office of Space Flight Development responsible for advanced technology, propulsion, space sciences, and space flight operations.

Just to give you the totals: there are in the Office of the Administrator, 105 persons. These include the Office of Public Information and the General Counsel's office.

There are 202 in the Office of Business Administration; 75 in the Office of Aeronautical and Space Research; 104 in the Office of Space Flight Development.

Now, the Office of Space Flight Development was created October 1, when NASA was created. It has been in existence about 7 months. It is still growing.

In other words, we have been carrying on a program and gearing up for the enlarged responsibilities.

So the 150 people that we are talking about are distributed, a fair number of them, in this group.

Does this show the breakdown?

Mr. ULMER. Sixty of the 150 will be going into the Office of Space Flight Development program.

Dr. DRYDEN. Yes.

Mr. MITCHELL. How many will you have, Doctor, when your headquarters employment is 486? How many of those will be in public information?

Dr. DRYDEN. I have read—486 is the final number; 29 in public information.

Mr. MITCHELL. Twenty-nine.

Do you have any questions on headquarters now?

Mr. KING. I have one or two.

Dr. Dryden——

Dr. DRYDEN. Yes?

Mr. KING. At NASA headquarters: your activities relate entirely to the administrative and technical supervision of the total NASA program.

Dr. DRYDEN. This is correct.

Mr. KING. You carry on no research here in Washington?

Dr. DRYDEN. No laboratories and no research.

Mr. KING. Is the increase from $4,864,000 to $6,409,000 for the headquarters?

Dr. DRYDEN. Yes.

Mr. KING. Is that increased in about the same proportion as the increase for your other activities, and the total, which is $86 million, to $94 million? In other words, is the pattern of growth about the same in all of your departments, including your headquarters?

Mr. ULMER. No, sir, Mr. King.

On page 5, again, there are three areas in which we have any substantial growth.

The major growth comes in the Space Project Center presently under construction at Beltsville, Md.

Mr. KING. It appears as item——

Mr. ULMER. Item 13, on page 5.

Mr. KING. Yes.

Mr. ULMER. It shows 720 increase in staff for Beltsville, 153 for the pilotless aircraft station at Wallops Island, Va., which is our small firing range on the Atlantic Ocean; and 150 additional people for NASA headquarters.

Now, the staffs of the various research centers, Langley, Ames, and Lewis, stay constant from 1959 to 1960.

Dr. DRYDEN. This was a policy decision made by the Administrator. When NACA was transferred to the new Agency, the decision was made that that effort would be held level in 1960, while we were organizing the space activities.

So that the decision was made that there would be no increase in personnel at the research centers, and that the only increase asked for would be that required to implement the new functions which were established in the new agency. That is the reason for this uneven distribution, if you think of it as that.

Mr. KING. Do I understand that the areas in which there is no increase represent areas of activity which you inherited from NACA?

Dr. DRYDEN. That is correct.

Mr. KING. Let's see. That stands for National——

Dr. DRYDEN. Advisory Committee for Aeronautics.

Mr. KING. Yes. And that has been in operation for some 40 years, hasn't it?

Dr. DRYDEN. Forty years, yes.

Mr. ULMER. That is right.

Mr. KING. And that, of course, had to do with aircraft of all types?

Dr. DRYDEN. Yes.

Mr. KING. Aircraft and space exclusively?

Dr. DRYDEN. Yes.

Mr. SIEPERT. An example of this kind of stabilization I think can be pointed out in the headquarters complement.

As Dr. Dryden pointed out, the Office of Aeronautical and Space Research is the headquarters technical group which oversees the planning and the execution of the work in the research centers. This is

where the aeronautical research work has been done for many years.

Now, that same group is of course now concerned with certain space research that is done in those centers. However, these same centers have their employment stabilized for this next year.

And our 1960 headquarters staffing for that equivalent technical counterpart in Washington, will remain at practically the same level.

The only addition is an increased complement in an office of research grants, which is an expanding program of greater support to research ideas in industry. And it takes technical people to run it.

My point is that we have not, then, increased headquarters technical or administrative staffing to handle our inherited NACA-type business. This is a buildup in order to stay on top of a broad new space research and development program.

Dr. DRYDEN. Another way of looking at it: the NACA budget was about $100 million. You are looking here at a multiplication of that by nearly 5, or an increase of about 400 percent.

The increase in the number of people, however, is only about 10 percent, I think, going to 9,988 as compared to 8,961, or an increase of 1,027 people, to handle $333 million worth of business. This is another way of looking at it.

You can see that the new functions are being discharged by contracting with other groups and outside groups, and we are limiting the personnel growth in the agency to the people that are required to manage this expenditure intelligently.

Mr. MITCHELL. Well, I note on page 3 that in the 1959 appropriation initially for S. & E., it was only $83.1 million, whereas you are asking for $94.4 in 1960. Yet you are asking for R. & D. almost $130 million in additional funds?

Dr. DRYDEN. That is correct, yes.

Mr. MITCHELL. I would like to ask—this will be—I think we can get this in the record, because it will apply to many of the locations that NASA is concerned with.

I note quite an increase in two items, namely, "Travel" and "Communications."

Dr. DRYDEN. May I discuss those generally, first, and then turn it over to Mr. Ulmer for some of the numerical background?

NACA was an agency which operated wholly within the United States. We had research work done at these major laboratories. NASA is an agency which is operating around the world.

There are tracking stations—the full committee has had a presentation of the location in South America, Spain, Australia, and so on.

In preparing our estimate, we had the experience of the Vanguard group, which was transferred to us on October 1st. We have some detail of what it took in running their minitrack network and their optical stations around the world in the way of travel.

Our estimates have been based on our own experience in NACA, in which the travel per man is relatively low, to the experience in a similar operation where the travel per man is pretty high.

The reason it is high is because there have to be frequent trips to these stations to supervise their operations, to calibrate their equipment, and so forth.

Furthermore, NASA is engaged, that is, will be engaged, in a program of international cooperation. We are directed by the law to cooperate with other countries, to see what we can do in this area that is sensible, anyway.

In connection with this program, very much more travel will be required than NACA ever had.

So the new functions have brought a new kind of responsibility involving travel. It has changed from a domestic operation to a worldwide operation.

Now, just to finish the travel story, Mr. Ulmer has a table that he might summarize, and we could perhaps put this in the record.

Mr. ULMER. Mr. Chairman——

Mr. MITCHELL. Would you like to put this in the record?

Mr. ULMER. I would be glad to, Mr. Chairman.

Mr. MITCHELL. If there is no objection, then it will be.

(The table referred to is as follows:)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Fiscal year 1960 estimates—02 travel

	Headquarters		Research centers and stations	Beltsville Center	Total
	Committee meetings	Employee travel			
Fiscal year 1958					
Number of man-years		166	7,638	143	7,947
Total travel obligations	$123,790	$63,570	$214,818	$399,610	$801,788
Average cost per man-year		$383	$28	$2,794	$101
Fiscal year 1959					
Number of man-years		280	7,669	441	8,390
Total travel obligations	$130,000	$449,405	$483,095	$500,000	$1,562,500
Average cost per man-year		$1,605	$63	$1,133	$186
Fiscal year 1960					
Number of man-years		446	8,090	1,062	9,598
Total travel obligations	$150,000	$1,150,000	$686,000	$1,195,000	$3,181,000
Average cost per man-year		$2,915	$85	$1,125	$331

Mr. ULMER. It gives some information concerning the fiscal 1958 experience of NACA, which averages out to somewhat less than $100 per employee for travel.

Now, at the time this budget was prepared for NASA, the only other experience we had as a guideline was the Vanguard experience. Their travel for a fiscal year averaged approximately $2,800 per employee.

So within these two limits, we had the job of estimating what the travel requirement would be for an agency that had not yet been established, whose full job had not yet been understood, and the magnitude of the program had not been developed.

But it works out so that the travel requirements come, for the headquarters employees, to something comparable to what the Vanguard experience was, with a slight increase in travel for our research centers and stations in view of their expanded responsibilities in having to do this type of space research.

Now, this table comes out so that the average travel per employee for the entire agency is something on the order of $330 for 1960, compared with our past experience of about $100 per employee.

Dr. DRYDEN. Just to illustrate what we are talking about in concrete terms. Many of you know that we have used, borrowed, so to speak, a radio astronomy telescope in England for following this last probe that went out into space beyond the moon.

This, of course, is equipment built for other scientific purposes. Before NASA was in the picture, the Air Force had installed certain equipment so that they could receive on the frequencies that were being used in satellites.

We just last week, I think, sent a technical man and a contract man to negotiate an agreement, that is, a contract, for the future use of that telescope in the space probes that are going to be fired within a few months from now.

Well, you see here are two men to England, and back. I don't remember what the numbers run. You have been to England and know that this is a sizable travel expense.

The network that we inherited from IGY, tracking stations located largely in South America, with some stations in Australia and South Africa, were put up under temporary agreements with these countries. We have had the problem and are in the middle now of negotiating agreements to continue to operate these stations in these countries.

Now, on the political side, this is done through State Department channels. But we also have to send our people down to Peru and Chile, first of all to decide just how we are going to operate them.

In those cases we have made contracts with local institutions to provide the major part of the people, so that we don't have to maintain our own nationals there at very high cost.

We will have a station manager who is a NASA employee. And we will probably use a commercial contractor in the logistic supply of the station. But there is certain travel on the part of our staff in connection with negotiating these agreements, and there will be later travel, as I mentioned, in being sure the equipment is properly calibrated and all the rest of it.

This is what we are talking about. It is quite different from any responsibility that we had in NACA.

Now, I think with this in the record you about have the travel story. If you want——

Mr. MITCHELL. Well, communication and travel are generally tied together, aren't they?

Dr. DRYDEN. Yes.

Mr. MITCHELL. And as your space research is stepped up—let me ask you if this is a fair statement concerning the increase insofar as these two items are concerned.

Dr. DRYDEN. Yes.

Mr. MITCHELL. You anticipate in fiscal year 1960 to have quite an increase insofar as space research is concerned, necessitating increased communication and travel with your minitrack stations.

Dr. DRYDEN. Particularly worldwide travel and worldwide communications. Teletype lines to Australia to get the information back.

Mr. MITCHELL. Yes.

Dr. DRYDEN. Previously this has either been paid by the IGY appropriation during IGY or by the military when the military had the responsibility for civil space operations, as they did pending the establishment of NASA.

Mr. MITCHELL. You actually really are getting into full operation in 1960?

Dr. DRYDEN. This is correct.

Mr. MITCHELL. Mr. King?

Mr. KING. Dr. Dryden, I notice the item for travel for Beltsville is $1,195,000, which is almost of the same order as the travel for the entire headquarters, which is $1,300,000.

Dr. DRYDEN. Yes, sir.

Mr. KING. I would like to know why that item is as high as it is.

Dr. DRYDEN. May I first say that we have mentioned that this center is under construction. You may wonder how they can travel when it doesn't exist. I think I ought to explain that.

The components of the Beltsville Center are in existence. When the Vanguard project was transferred from the Navy, we had to find space for them outside the Naval Research Laboratory, immediately. The way we did that was to persuade the Navy to assign a building belonging to the Naval Gun Factory that had been used for storage, just outside the fence of the Naval Research Laboratory. We converted that building to house temporarily the Vanguard group. They will move into Beltsville when Beltsville is finished.

There is a group dealing with the theoretical side of space science, which will be using high speed computing machines when they get into the Beltsville area. They are temporarily located in a rented building at Silver Spring.

The group running Project Mercury is at present located in buildings at Langley Field, Va. They are a part of the Beltsville Center.

So the Beltsville staff is in active operation, even though there are no buildings yet at Beltsville. This is what I am trying to say.

Mr. Vaccarro, sitting on my right, will be the business manager of this complex.

Now, this group is the field group concerned with tracking, data collection, and data analyzing. You take in this particular case, the communications will be brought into this area.

Perhaps you want to break this down a little more, Mr. Ulmer?

Mr. ULMER. We have another breakdown that covers the communications area, Mr. King. I would like to put this table in the record if I may. Over $2 million of our $3.8 million communication bill relates to the operation of the Beltsville Space Center. Most of that is in connection with the leased-line type of activity Dr. Dryden mentioned and also in the communications required in connection with the minitrack and Project Mercury worldwide tracking networks.

(The table referred to is as follows:)

National Aeronautics and Space Administration

Fiscal year 1960 estimates—04 Communications

	Headquarters	Langley	Ames	Lewis	High-speed	Beltsville	Wallops	Offices	Total
Fiscal year 1958:									
Local telephone and exchange service	$17,666	$8,981	$14,411	$15,997			$948	$423	$58,426
Long distance toll charges	12,610	21,011	11,421	21,958	$6,512		3,485	909	77,906
Leased lines									
Telegraph service	2,254	1,935	182	3,918	131		105		8,525
Penalty mail	79,491								79,491
Total	112,021	31,927	26,014	41,873	6,643	(1)	4,538	1,332	224,348
Fiscal year 1959:									
Local telephone and exchange service	18,000	9,500	15,000	17,000		$50,400	950	550	111,400
Long distance toll charges	28,500	21,500	11,800	20,000	7,700	40,000	3,950	1,800	135,250
Leased lines	5,000				84,000				89,000
Telegraph service	10,000	2,000	200	3,000	300	7,000	100	200	22,800
Penalty mail	80,000								80,000
Total	141,500	33,000	27,000	40,000	92,000	[2] 97,400	5,000	2,550	438,450
Fiscal year 1960:									
Local telephone and exchange service	30,000	9,500	15,000	19,000		120,000	16,000	600	210,100
Long distance toll charges	100,000	21,500	12,800	22,000	8,000	80,000	40,000	5,400	289,700
Leased lines	180,000				106,500	1,890,000	462,000		2,638,500
Downrange and firing control, communication systems							370,000		370,000
Telegraph service	40,000	2,000	200	4,000	500	13,000	108,000	1,000	168,700
Penalty mail	150,000								150,000
Total	500,000	33,000	28,000	45,000	115,000	2,103,000	996,000	7,000	3,827,000

[1] Funded under appropriation "U.S. satellite, Department of Defense". Details not available.

[2] Additional communication services funded under appropriation "U.S. satellite, Department of Defense". Details not available.

SUMMARY OF SPECIALIZED SERVICES REQUESTED FOR THE FISCAL YEAR 1960

	Downrange and firing control communication systems	Leased lines
NASA Headquarters		$180,000: 1 Headquarters to Atlantic Missile Range; 1 Headquarters to Pacific Missile Range; 1 Headquarters to Jet Propulsion Laboratory; 1 Headquarters to Langley Research Center.
High-Speed Flight Station		$106,500: X-15 Tracking Range.
Beltsville Space Center		$1,890,000: Minitrack global range system, $1,080,000; Project Mercury global range system, $800,000 (last 2 months of fiscal year 1960).
Pilotless Aircraft Station	$370,000: Downrange intercommunication system; operational and firing control, public address and countdown intercommunication network within Wallops and Chincoteague areas.	$462,000: 2 Wallops to Langley Research Center; 2 Wallops to NASA Headquarters; 6 Wallops to Beltsville Space Center; 1 Wallops to FAA Controller at New York; 2 Wallops to Bermuda; 2 Wallops to Atlantic Missile Range.
Total	$370,000	$2,638,500

Mr. ULMER. Now, the travel for the Beltsville people averages out to about $1,000 an employee. It covers the travel of all 1,247 people that are in the budget for the Beltsville Space Center.

Mr. KING. Does this cover foreign travel?

Mr. ULMER. Yes, of all those people.

Mr. SIEPERT. All told.

Mr. KING. In other words, they would have to go to Australia and elsewhere?

Mr. ULMER. Yes, sir.

Mr. KING. To negotiate for these stations and to service or at least check on them from time to time?

Mr. ULMER. Correct.

Mr. KING. And all of that would be covered by this budget?

Mr. ULMER. Correct.

Dr. DRYDEN. I think we should repeat here what we said in the main committee about the Beltsville activity, plus the tracking activity.

The whole purpose of putting satellites in the air is to get the information received at these stations around the world transmitted to a center where it can be analyzed, that is, put through whatever computations are necessary. This is a tremendous job.

I believe that there are miles and miles of magnetic tape records obtained from these tracking stations which have to be fed into computers in order to get the data out of them. This is the payoff in the whole operation. Otherwise, the rest of the expenditure is just fireworks or making an impression.

Mr. MITCHELL. Is that part of this communication item?

Dr. DRYDEN. Yes. That is the major part of it.

Mr. MITCHELL. Your magnetic tape?

Dr. DRYDEN. It is getting the information that you have gotten by radio from the satellite. In most cases it is recorded on magnetic tape, which is shipped home. In other cases, when you are trying—when one of these firings is made, you want to know if the thing is in orbit. So you are anxiously waiting for this teletype message, or telephone

message. "Did you fellows pick up anything, and what time did you pick it up."

Mr. MITCHELL. I think that is important.

Dr. DRYDEN. Yes.

Mr. MITCHELL. This includes other than man-to-man telegraphic or telephonic messages.

Dr. DRYDEN. It is a transmission of data, as well. I haven't made that too clear.

Mr. KING. Doesn't that come in over wires?

Dr. DRYDEN. Yes.

Mr. KING. It doesn't require somebody to personally go and pick up that information, does it?

Dr. DRYDEN. It depends——

Mr. ULMER. It is the lease of those wires. That is the expensive part of this item.

Mr. KING. Do you have private wires?

Dr. DRYDEN. We have to contract for leased lines. But most of them you lease them for periods. You seldom lease them 24 hours a day year around or anything like that. But during the time of an actual firing and for the periodic transmission of data, you have to have those lines for your use and yours only. The same thing would be true in an airplane project like the X–15, although this is wholly within the United States.

There is a tracking range in connection with the flights of the X–15, extending between Wendover, Utah, and Edwards Air Force Base.

Now, to transmit information from one station to the other and to Edwards Air Force Base, we lease lines from a telephone company. This is a part of the communication expense.

So it is not just telephone conversations between people. I would like to get that pretty clearly in the record.

Mr. KING. Now you mentioned miles of tape.

Dr. DRYDEN. Magnetic tape.

Mr. KING. Magnetic tape. Where are those miles of tape? Are they at the tracking stations?

Dr. DRYDEN. At the tracking stations.

Mr. KING. So the information is sent from the satellite, and transmitted to the tracking stations, on to the tape?

Dr. DRYDEN. This is part of the information.

Mr. KING. It is relayed on to the central office?

Dr. DRYDEN. That information is usually sent by air transportation.

Mr. MITCHELL. The tape itself?

Dr. DRYDEN. The tape itself. But the tracking information is something that the control center needs to know right away.

If we sent all the data that is received from a satellite over a wire line right away this bill would be astronomical.

Mr. KING. I see.

Dr. DRYDEN. We just cannot afford to do that.

Mr. KING. So what you send is the tracking information?

Dr. DRYDEN. The tracking information.

Mr. KING. And the information on the tape. They just send the tape?

Dr. DRYDEN. The key information.

Now the tape has usually the scientific records, the measurements of the radiation in the sky, for example. By teletype you might say

that the chap has looked at the record and it is clicking awful fast, so many clicks per minute, to give them a rough idea of what you are getting. But the records, the accurate records to be worked up, are in the form of magnetic tape which would be shipped in.

Mr. KING. Now you mentioned all of these computations that have to be made.

Dr. DRYDEN. Yes.

Mr. KING. Being a nontechnical man, I do not understand what these computations are. Will you give me an example?

Dr. DRYDEN. Let me put it this way. The typical apparatus that has been used so far in measuring the radiation field of the earth is a so-called geiger counter. It is a glass tube with some pieces of metal on the inside and a particular gas. When radiation strikes this tube, it produces an electrical impulse. There is an electronic circuit in the satellite called the counting circuit, which will send the signal say every time it has 50 counts or 100 counts or whatever scale you want to build into the apparatus. Each one of these counts means that an electron, a charged particle, that is, is passed through this tube.

Well, what would then be obtained on the ground would be a certain number of impulses coming down on the tape. They would make a signal. And if the radiation is very high, you will get a lot of these following each other very rapidly. If the radiation is small, they will be more infrequent.

Now the magnetic tape, then, has merely a record with time of the number of—when these signals are received. This is what you have.

You say "At 1 o'clock, 1 minute after and 10 seconds, I got a signal, and 20 seconds later I got another one, and 50 seconds later another one." You get a record, then, of when each one of these signals is received.

What the scientist has to calibrate from the rate of these signals is what the strength of the radiation field is. What he has to do is count the number of these things in a given time.

They are gradually developing mechanical instrumented ways of doing this, because it would be impossible to take this mile of stuff and by hand count off and read the times.

This by itself is not very useful to him unless he knows where the satellite is when he made this measurement. He has to know how far it was away from the earth and exactly what position it was in. This, you see, comes from the other records, from the tracking information, from the angle at which the tracking antenna was pointed or in the case of the minitrack it is more complicated than that. But from this information, you can locate the satellite in space.

What the scientist gets out of it at the end is finally, after lots of records, kind of a map of how this radiation field is distributed around the earth.

So in order to get from a film that just has signals on it at varying times to his final plot of the radiation intensity around the earth, he has a lot of arithmetic to do, and so much to do that in order to get results in any reasonable time you use these high speed computing machines as a means of reducing the results—putting in the calibration factors and coordinating the various records.

Mr. MITCHELL. Anything further?

Mr. KING. I do not think so.

Mr. MITCHELL. Doctor——

Dr. DRYDEN. May I just mention this? You may think that chart is a classified chart.

At various times questions have been raised. We do not like to publish aerial photographs of our laboratories, with keys of all the locations of all the installations. So the word "confidential" is on there, not because it is a picture of the laboratory, because anybody flying over it can take a picture of the laboratory, but because this particular one has a lot of numbers on it and illustrates exactly where each structure is. So that chart is confidential.

Mr. MITCHELL. I assume, Doctor, it has been declassified since there was nothing on it in the way of erasures or ink.

Dr. DRYDEN. We do not publish a picture with a key to all the installations.

Mr. MITCHELL. Doctor, I note that as far as travel and communication—I think possibly we can wrap this up with this question.

Dr. DRYDEN. Yes, sir.

Mr. MITCHELL. Principally the increase in these two items is at headquarters of NASA here and at Beltsville?

Dr. DRYDEN. That is right.

Mr. MITCHELL. And these two components of NASA are charged with the responsibility of space research, the firings, the collection of the data?

Dr. DRYDEN. Yes.

Mr. MITCHELL. And evaluation of the data as a result of these space probes and satellite launchings, is that correct?

Dr. DRYDEN. That is correct. That is a very good statement.

Mr. MITCHELL. Now the Pilotless Aircraft Station.

Mr. KING. That is where?

Dr. DRYDEN. That is at Wallops Island, Va., which is on the Atlantic coast, just below the town of Chincoteague, as many of you may know.

This is a picture of it. The ocean is to the right.

There are at this station facilities for making aerodynamic and structural measurements on models fired with rockets. This has been in operation under NACA for—what, 14 years?

Mr. ULMER. Fourteen years.

Every missile or airplane that you have heard about has had a model of it fired at Wallops Island to investigate its stability, its drag, and its general behavior.

In addition we have done general research on such problems as heating on nose cones of ballistic missiles.

We have through these 14 years increased the capability of making measurements, beginning at speeds near the speed of sound. In fact, this station was set up because there was no way in the wind tunnel at that time to make measurements at the speed of sound. They had to be made in flight. This technique proved to be very valuable.

The speed of sound is about 700 miles an hour, roughly, or what we call mach 1—that is one times the speed of sound.

Mr. MITCHELL. Yes.

Dr. DRYDEN. Through these years we have developed the means and techniques with rockets of moving to a speed up to values of about 16, mach 16, or 16,000 feet a second, roughly, and making measurements of reentry test vehicles. This was done by using as many as five stages of rockets—that is five rockets strung end to end.

They very rapidly have been approaching the speeds necessary to put satellites in orbit with these rather inexpensive solid-propellent rockets. We made a presentation of a satellite vehicle Scout, which will attain a goal that they have been working toward for 14 years.

At this Wallops station, we will probably fire this particular small satellite vehicle. The bulk of the firings, of course, will be done at Canaveral. For the Thor and Atlas firings we will use the Atlantic Missile Range or in some cases the Pacific Missile Range.

Mr. MITCHELL. Doctor, in connection with the travel and communication items; what is the reason for the increases in these items at the Pilotless Aircraft Station? The firings that you are anticipating?

Dr. DRYDEN. Well, it is associated with some expansion of the station in numbers of people.

The budget provides an increase from 97 to 250 people.

At this station we are providing better electronic equipment to make these experiments. The volume of the work will increase somewhat because we are able to do many simpler investigations that do not need to tie up the large range at Canaveral.

I have said in some hearings: If you have a job to move something, you adjust the size of the truck to the load as you are doing it. So the one-truck jobs we will do here. When you get to the 20-ton or so, you do that at Canaveral. It does not make any sense to use Canaveral for a job that can be done at a place like this.

Mr. MITCHELL. There is quite a sizable increase in those two items from 1959. Only $5,000 each for travel and communication?

Dr. DRYDEN. Yes.

Mr. MITCHELL. Going to, as far as travel is concerned, for this division of your agency, to $200,000 and communication going from $5,000 to almost $1 million.

Dr. DRYDEN. The group that has been there have not required very much travel bcause of the way in which it has been operated and its place in the organization. It has been operated as a field station of Langley, with a resident crew that did not contain any of the scientific and professional people. They were located at Langley and their travel was carried in the budget of the home station.

Now with the change in function in which Wallops is going to be serving the space flight group——

Mr. MITCHELL. Let me interrupt you again, please, right there at that point.

Dr. DRYDEN. Yes.

Mr. MITCHELL. There has been travel, but it has been budgeted as far as Langley Research Center was concerned——

Dr. DRYDEN. Yes.

Mr. MITCHELL. Not specifically to the Pilotless Aircraft Station, as is being done this year?

Dr. DRYDEN. It was a subordinate unit. While we have not announced this I think yet to the press—and we are going to do it very soon I believe—this station will be set up as a unit in itself serving the whole organization, that is serving Langley operations in airplane model testing, missile testing, and research of that nature, and it will serve the Beltsville center in trying out certain aspects of satellite problems. This means that more of the travel will appear at this independent station than occurred before when it was a subordinate station of a major laboratory.

I think that is the fact, sir.

Mr. SIEPERT. Mr. Chairman, I am not sure we quite answered your question. Before we got into this much heavier program of rocket work at Wallops, practically all of the technical staff who were responsible for the rockets that were being fired off this isolated beach were located at Langley, and they were flown up there for a particular firing, you see. So whatever travel they had in connection with this project was not assigned to the Wallops station.

The second thing is when you expand the Wallops facilities as we are doing to handle larger rockets, such as the Scout vehicle——

Dr. DRYDEN. Yes.

Mr. SIEPERT. Here we are dealing with a rocket that can be fired from Wallops and be capable of orbital flight. When this happens, then, the launching base needs to build into its setup an extensive communications network, to know where the vehicle is in flight at all times; that it is off on the proper launch and the like.

Mr. MITCHELL. May I interrupt you?

Mr. SIEPERT. Yes, sir.

Mr. MITCHELL. Similar to Vandenberg and Canaveral?

Mr. SIEPERT. Yes, but on a completely different magnitude. It costs money, but not that kind of money.

Mr. MITCHELL. It is generally for the same purpose?

Mr. SIEPERT. Yes, that is right. However, our budget won't show these costs under Patrick Air Base, and yet we are firing at Patrick or Cape Canaveral. These costs, to the extent that we use the cape's facilities, are reimbursable costs which are a part of the launching expense of the vehicle. These costs are covered in another part of this budget as a vehicle expense.

Dr. DRYDEN. We reimburse the Air Force, say, for firing a Thor for us at Patrick, and a lot of the costs connected with that launching appear simply as a transfer of funds to the Air Force.

Mr. SIEPERT. These launching costs are quite large. They will run a quarter of a million to $400,000 per firing at the cape. But we show for Wallops the total lumped cost of all operating and communications services at Wallops, regardles of how many, actual rockets we fire from that beachhead.

Mr. MITCHELL. Anything else?

Mr. KING. No.

Mr. MITCHELL. Do you have any questions?

Mr. CARSTARPHEN. No, sir.

Mr. MITCHELL. Any time counsel has any questions, I hope he will please say so. Do you have any questions to date?

Mr. CARSTARPHEN. No.

Mr. MITCHELL. One other item, which was quite interesting, that counsel pointed out to me. I note throughout you have some budget items for uniforms. I thought that was quite unusual for a civilian agency. Is that for guards, your security people?

Mr. ULMER. Mr. Mitchell, that is primarily for guards at our research centers. The Federal Employees Uniform Act of 1954, I believe, permits payments up to $100 per employee for types of people that require uniforms in the performance of their duty. Most of our requirements come in connection with firefighters, guards, nurses, and people who occupy positions of that type.

Mr. MITCHELL. One other thought occurs to me. I have no idea that you may have these figures. But since the travel as far as Wallops was concerned was previously budgeted with Langley and since there is quite a sizable increase, do you have any figures on travel for these personnel that are actually at Wallops working, but were budgeted for Langley?

Mr. ULMER. We do have some figures of that type, sir, but not with us. We can get them and put them in the record.

Mr. MITCHELL. I think it would be important.

Mr. ULMER. Glad to.

Mr. MITCHELL. In view of the sizable increase in travel.

If you would file that with the committee.

Mr. ULMER. To simplify administrative procedures in the agency, travel costs are paid by the location payrolling the employee. So the Langley people that went up on travel to Wallops to be there during a particular firing were paid by the Langley Laboratory.

We will pull those costs out to show what they were.

NOTE.—Approximately $7,000 was expended for this purpose during the first 9 months of the fiscal year 1959.

Now, Wallops Island is expanding, with its own staff being increased to 250 permanent people. The travel costs in 1960 of those people at the station will be shown as a Wallops cost. In addition, the changing role of the station in the overall NASA program previously discussed by Dr. Dryden will require a substantial increase in travel by the staff of this activity. This is the major reason for the increase in travel requested for the station in 1960. Next year we will have a better record of experience to serve as a base for our estimates.

Mr. MITCHELL. Now are they being—they are, of course, being assigned permanently?

Mr. ULMER. Correct.

Mr. MITCHELL. But will they be living at the facility itself?

Mr. ULMER. Yes, sir.

Dr. DRYDEN. They will live in that community.

Mr. MITCHELL. Within the community.

Mr. King, unless you have something further, I think—I think we have covered the headquarters. We have had some general questions that will apply to other locations.

Mr. KING. I have one general question, Mr. Chairman.

Mr. MITCHELL. All right.

Mr. KING. Dr. Dryden, the inevitable question will be asked us, who will be charged with sponsoring this bill on the floor of the House?

Dr. DRYDEN. Yes.

Mr. KING. The inevitable question being: "Well, these figures look rather high. Isn't there some way we can trim." How can we be assured that these figures are justified? How can we be sure that there is no padding here? I mean these are inevitable questions.

Dr. DRYDEN. Yes.

Mr. KING. You understand the general climate in which we are traveling?

Dr. DRYDEN. Yes.

Mr. KING. Since we are not technical men, we are not prepared to justify every dollar here. We have to take your word for it.

Dr. DRYDEN. Yes.

Mr. KING. But would you care to state something into the record covering the general point, to indicate that you are satisfied that these figures represent the absolutely irreducible minimum under which you could not operate efficiently and do the job that has been assigned to you?

Dr. DRYDEN. Yes. Perhaps two statements will help.

First of all, we consider that a policy has been established by Congress and by the Administration that they want to make this country a leader in space technology and space exploration.

To do that, we have estimated the rate at which we think we can go to do this. You have heard the testimony, that it will take about 18 months to accomplish the same weight capability in space that our competition already has demonstrated.

We feel that this is a minimum budget to fulfill that kind of responsibility.

Now if Congress wants to establish a different policy, why that is a different matter. But if we are to meet the responsibilities that are put upon us by the act and by the statements of policy, both of Congress and of the Administration, we do not see how we can do it with less. We have not put into this budget any contingencies. We have said throughout our discussions both within the Administration and in the Congress, that we are in a new field and a rapidly changing field. We do not have a basis always of determining to the last penny what things are going to cost.

The R. & D. money is being provided on a no-year basis. We are going to spend it just as efficiently and as effectively as we can. If we have some of it left over to go into the following year, then we don't have to ask as much in the following year.

On the other hand, we have said that if we find that conditions beyond our control, either technical obstacles that we run into or similar things, demonstrate the need for more funds, we will be back through channels to the Congress with a request of what we think we need to meet this responsibility.

Do you want to add anything?

Mr. SIEPERT. No.

Mr. MITCHELL. Doctor——

Dr. DRYDEN. As I say, if you decide you don't want to go ahead this fast, then obviously you don't have to spend this much money.

Mr. KING. My question was not meant to infer for a minute an abandonment of stated policies and objectives, Dr. Dryden.

Mr. MITCHELL. In view of the comments of this subcommittee, I think that is unanimous. If you can say this and if it doesn't go into classified matter——

Dr. DRYDEN. Yes.

Mr. MITCHELL. You might be general in it. But to illustrate the degree that your work will be stepped up—I am talking about NASA as compared with the work of NACA last year. Could you generally state the number of firings you anticipate in fiscal year 1960 as compared with the previous year?

Dr. DRYDEN. Well, during this fiscal year approximately 12 firings will take place.

During the fiscal year 1960 we will average something better than two firings a month.

Mr. MITCHELL. Will those be NASA supervised or——

Dr. DRYDEN. Yes.

Mr. MITCHELL. And some will be your firings and some will be service firings?

Dr. DRYDEN. There will be additional firings in the military program. But I am talking about those in the NASA scientific program only.

Mr. MITCHELL. You will average around two firings a month?

Dr. DRYDEN. Yes. Of course the rough measure is five times as much money. That must mean not exactly the rate of five times as much, but something commensurate with that. It is a tremendous step up in activity and responsibility, a different type of responsibility.

Mr. KING. Pardon me. You said five times as much money as what?

Dr. DRYDEN. Well, the 100 million NACA up to 485 million in this budget.

Mr. MITCHELL. How many firings at the end of this fiscal year do you anticipate that your agency will have been responsible for?

Dr. DRYDEN. Well, we have to be careful about definitions. Everything that we have fired so far was actually started when the responsibility lay with the Department of Defense. In other words, we have been completing projects which were initiated before NASA existed.

Now I believe the first of the firings which we initiated after NASA was created will come in about 2 months, something like that.

The rest of this year there are three or four firings—I don't remember exactly. The rate really steps up as you go in the next calendar year.

Mr. MITCHELL. The next calendar or fiscal year?

Dr. DRYDEN. The next calendar year the rate will begin to go up.

Mr. SIEPERT. You made one comment I think you might want to say something further on.

You said that as the rate of expenditure went up the numbers of firings will go up.

Dr. DRYDEN. Oh, yes.

Mr. SIEPERT. This is true, except we need to remember there is another trend involved here. The big crash program here is to get firings which have larger payloads. This means new, larger boosters.

Mr. MITCHELL. More expensive.

Mr. SIEPERT. And those cost more per vehicle than the others. So that dollars alone are not an indication that firings will run in proportion.

Mr. MITCHELL. We should have that clarified for the record. I think certainly when this matter is brought to the floor—this may be a difficult thing to answer, except in the most general type of terms.

Dr. DRYDEN. Yes.

Mr. MITCHELL. But do you have a mean cost figure that you can give us as far as launchings are concerned?

Dr. DRYDEN. Well, this is a very changing figure. At the present time, these vehicles based on the Thor and Atlas run in the range of $2½ to $4½ million for just the vehicle and launching part of it, and not the payload. The payload may cost in the order of another $1 million.

Now the vehicles that we have available are not as efficient as we would like to see them. This is the reason the number of firings is from some points of view relatively small at the moment.

By the end of this year we will have much more efficient vehicles. A Scout, for example, which we expect will cost about half a million dollars each will put up something of the order of 150 pounds into orbit, whereas the Explorer and Juno II's that we have been using put up only—well, the Explorer only 20 pounds and Juno II about 80 pounds.

So we are not—you can say—in fact the question is raised "Why do you do any firings at all now?" Well, you have to get experience with things you have. You can't work with things that you don't have. But we are not doing a large number of firings with the relatively inefficient vehicles.

Mr. SIEPERT. Dr. Glennan in a speech I believe within the last 2 months used, I think, a handy reference figure, that you might be interested in. He pointed out, as I recall it, that the present firings with the vehicles that we now have, mean we are actually devoting as much as 10,000 pounds of booster and carrier for every pound of instrumentation that we get up in the sky.

This budget is in the middle of the development of so-called second generation vehicles, which will improve that factor dramatically, to the point of 1,000 pounds of booster and carrier will lift 1 pound. Finally, in the longer-range programs such as the million and a half engine, if that comes to fruition the way we hope, you will have a still further dramatic reduction. I think the figure is something as low as 200 pounds per pound of payload.

Dr. DRYDEN. I think so.

Mr. SIEPERT. We think that will be really dramatic progress over a very few years' time.

Mr. MITCHELL. Let's go off the record.

(Discussion off the record)

Dr. DRYDEN. Mr. Chairman, I would like to offer the services of Ralph Ulmer to work with the counsel on any information that you want of this kind.

Mr. CARSTARPHEN. Thank you.

Dr. DRYDEN. Of course you remember Jim Gleason is our contact man, but he has four subcommittees and can't do it all. I think it would go a bit faster if we designate Ralph to work with you and get you anything you want.

Mr. KING. Still off the record.

Mr. MITCHELL. Off the record.

(Discussion off the record)

Mr. MITCHELL. Dr. Dryden, what I would like for you to submit for the record is a general or probably a fairly detailed account of the activity of each of the divisions of NASA, together with your statement concerning items where you are asking this year an increase in appropriation over fiscal 1959.

Dr. DRYDEN. Yes.

Mr. MITCHELL. With your explanation for the need for additional funds.

Dr. DRYDEN. We will be very happy to do this, Mr. Chairman.

(The matter referred to is as follows:)

National Aeronautics and Space Administration

Salaries and expenses appropriation, fiscal year 1960

Activity	Function	Increases requested in fiscal year 1960	Purpose and need for increase
NASA Headquarters	Determine major policy, assign and coordinate programs, execute business management operations.	$1,544,150 (150 new positions).	Additional staffing for executive, research, development, and business administration functions, necessary increases in travel, communications, and other objects ($1,544,150).
Langley Research Center	Research on aerodynamic, structural, and operating problems of ballistic missiles, aircraft, satellites, and spacecraft.	$2,041,000 (no new positions).	Additional cost in 1960 of full-year employment of positions added in 1959 ($688,600); additional tabulating equipment rentals and utilities ($225,000); necessary increases for contractual services, supplies, and equipment ($1,115,400); and increases for other objects ($12,000).
Ames Research Center	Research on problems of ballistic missiles, aircraft, satellites, and spacecraft.	$1,864,850 (no new positions).	Additional cost in 1960 of full-year employment of positions added in 1959 ($372,700); additional tabulating equipment rentals and utilities ($246,000); necessary increases for contractual services, supplies, and equipment ($1,244,850); and increases for other objects ($1,300).
Lewis Research Center	Research on propulsion systems for aircraft, missile, and spacecraft.	$4,127,000 (no new positions).	Additional cost in 1960 of full-year employment of positions added in 1959 ($709,839); additional tabulating equipment rentals and utilities ($654,000); necessary increases for contractual services, supplies, and equipment ($2,633,531); and increases for other objects ($129,630).
High-Speed Flight Station	Flight research on problems of manned supersonic and hypersonic aircraft and spacecraft.	$520,900 (no new positions).	Additional cost in 1960 of full-year employment of positions added in 1959 ($85,246); additional tabulating equipment rentals and utilities ($11,700); necessary increases for contractual services, supplies, and equipment ($396,354); and increases for other objects ($28,600).
Space Projects Center	Planning, research, coordination and conduct of space flight programs, and analysis of data obtained.	$12,105,150 (720 new positions).	Continued staffing for scientific and supporting space operations at the Beltsville Space Center ($7,193,250); necessary increases for travel (including foreign travel in connection with tracking networks) ($1,140,000); and communications ($2,005,600); additional tabulating equipment rentals ($1,529,000); and increases for other objects ($137,300).
Pilotless Aircraft Station	Free-flight research on problems of ballistic missiles, aircraft, satellites, and spacecraft.	$2,384,080 (153 new positions).	Increased staffing for operations under a major increase in vehicle launching schedules for which extensive new facilities are being built ($1,029,610); necessary increases for travel ($195,000); and communications ($991,000); additional tabulating equipment rental and utilities ($74,000); and increases for other objects ($94,470).
Liaison and Coordination Offices	Coordination of NASA programs with the manufacturers, Department of Defense, and other Government agencies.	$58,870 (4 new positions).	Increase in staff of Western Coordination Office to serve the area in which a large part of NASA's research and development work is being carried on ($21,105); and necessary increases in travel, supplies, equipment, and other objects ($37,765).
Totals		$24,646,000 [1] (1,027 new positions).	

[1] Includes $1,532,698 increase required for contractual services, supplies, and equipment funded under the R. & D. appropriation title.

Mr. MITCHELL. Now, Mr. King, do you have any additional questions concerning any of the divisions or any general questions?

Mr. KING. Could I ask just one or two general questions?

Dr. DRYDEN. Yes.

Mr. KING. All of your testimony, of course, goes to NASA. We know that the services and ARPA have their program. Now you correlate many of your efforts with them, is that not correct?

Dr. DRYDEN. Yes.

Mr. KING. There is joint use of facilities. For example, Canaveral is technically an Air Force installation?

Dr. DRYDEN. This is true.

Mr. KING. But it is used jointly, am I correct, by all the services?

Dr. DRYDEN. Yes.

Mr. KING. And by NASA?

Dr. DRYDEN. Yes. The Canaveral is operated by the Air Force. All the services and NASA use it. It was used by Vanguard, in the original IGY satellite.

There is coming into the picture the Pacific Missile Range, which is being operated by the Navy. Vandenberg, of course, is an operational training base to the north of the Pacific Missile Range.

We are talking about the same geographical area, but the missile range is distinct from Vandenberg.

Mr. KING. Is Vandenberg Air Force?

Dr. DRYDEN. Vandenberg is an Air Force operational and training base.

Mr. KING. Like Canaveral?

Dr. DRYDEN. No. Canaveral is a research and development place only. They do not—except in a very limited sense—use Canaveral to train troops, for example, to fire missiles. This is to be done at Canaveral. You notice by the paper that the British troops to fire Thor are being trained at Vandenberg.

Mr. KING. You said Canaveral a minute ago. You meant Vandenberg?

Dr. DRYDEN. Troop training at Vandenberg. Canaveral did a very limited amount of this. Canaveral is research and development.

Mr. KING. Now—pardon me.

Dr. DRYDEN. Just one more sentence. The Pacific Missile Range is the only place we can fire in this country with safety in a polar orbit. This is the reason for going there.

Mr. KING. Well, now, what about the joint cost of Canaveral? Is any of that separate in this?

Dr. DRYDEN. There is a fee on every launching. It amounts to something in the order of a quarter to half a million dollars. Mr. Siepert was referring to this, although he didn't spell it out completely. But as a part of the launching of a Thor, which we do through the Ballistic Missile Division of the Air Force, whose headquarters, you recall, are out in California——

Mr. KING. Yes.

Dr. DRYDEN. They do control the Thor supply and firing. We would reimburse BMD for the cost of the Thor, that is the factory cost of the vehicle, and for the operations necessary to get it ready to be launched and for the launching. And in that there is something in the order of a quarter to half a million dollars, which goes to Canaveral as a fee for this operation.

I mentioned, you recall, $2½ to $3½ million, or $4 million per firing. A quarter to a half million dollars of that represents a fee that goes to Canaveral for the firing.

Mr. SIEPERT. It is fairly substantial.

Mr. MITCHELL. You are satisfied with the prevailing rate that goes down there?

Dr. DRYDEN. We look into it very carefully to see that no costs not properly chargeable to us are included. This is Mr. Siepert's job.

Mr. MITCHELL. You don't think they are making money off of NASA?

Dr. DRYDEN. They won't if we can help it.

Mr. SIEPERT. I don't know if we can answer that question conclusively but we believe the costs are fairly determined. We have to trust the Air Force accounting records, of course.

But these costs do come to a fairly substantial item, which, is carried in another part of the appropriation before one of your other subcommittees.

To give you just an example: on page 289, the cost in 1960 of developing the Delta space flight vehicle is estimated at $13,300,000, but on page 290, $5 million of that is listed as "range and launching services."

Dr. DRYDEN. That is for 12 vehicles.

Mr. SIEPERT. Yes.

Dr. DRYDEN. So 12 into $5 million is about 400-and-some thousand dollars. It is within the range that I mentioned.

Mr. KING. Well, does NASA actually produce these missiles?

Dr. DRYDEN. No, sir.

Mr. KING. You actually do not produce them?

Dr. DRYDEN. We budget for them and reimburse the military services for them.

In other words, the costs of the Thors and Atlases that we use are not a free gift from the ballistic missile program. We have to reimburse the production costs of those specific ones.

Mr. KING. In all of these installations, of which you have—what, 10 or so?

(Dr. Dryden nods.)

Mr. KING. None of them actually turn out missiles?

Dr. DRYDEN. No.

Mr. KING. They are research——

Dr. DRYDEN. They are research laboratories.

Mr. KING. You actually commission the services of private agencies to go into the actual business of turning out missiles?

Dr. DRYDEN. That is correct.

Mr. ULMER. That is why that cost shows under the R. & D. section. It is done under a contract with the military services or under a contract with a company, and it shows under the research and development section.

Mr. KING. And when they are produced, does title vest in NASA?

Mr. ULMER. Correct, sir.

Mr. KING. Do you have stockpiles of these missiles?

Dr. DRYDEN. No, indeed.

Mr. ULMER. Of the smaller ones, we do.

Dr. DRYDEN. The smaller ones, like the ones we use in research at Wallops Island.

But each Thor and Atlas we use must be obtained at the time it does not interfere with the ballistic missile development schedule.

In other words, the Air Force has a production line in the Douglas plant on Thor's and in Convair on Atlases. They turn them out at the rate of a certain number a month.

Now, we have to go in there as much as 9 months or a year ahead of time and say at that time, we would like so many Atlases or so many Thor's. "Can you make them available at that time? If not at that time, when can you make them available to us?"

Mr. KING. How does all of this research that you are conducting reflect itself in the final products? Do you pass on to the Army the results of your findings?

Dr. DRYDEN. Yes.

Mr. KING. And say, "Now, these are the specifications that we want, and will you build these specifications into a missile for delivery 9 months from now"?

Dr. DRYDEN. This is essentially correct.

In some cases there are no alterations required, but in others—you mount these upper stages for space work on top of a Thor. That takes a certain amount of modification of the Thor, which we have to pay for, and we have to order that about 9 months ahead.

Mr. KING. Well, would you ever enter into a contract directly with a private company, such as Chrysler or Rocketdyne?

Dr. DRYDEN. Yes.

Mr. SIEPERT. We have.

Dr. DRYDEN. We have. And in these cases, however, we must clear with the military on the assignment.

Now, the Delta is the Thor booster, with a second stage Vanguard engine on top of it, and a third stage Vanguard engine on top of that. That contract is directly with the Douglas Co.

We can't get any Thor's and Douglas can't give us any Thor's, except according to a schedule fixed by the military.

Mr. KING. Why is that?

Dr. DRYDEN. Well, because the Thor is developed as a ballistic missile. That has a higher priority than space. I mean, if the boosters are needed for a ballistic missile commitment, that takes priority.

Actually, they are developed——

Mr. MITCHELL. It has a military priority.

Dr. DRYDEN. Military priority.

Actually, they have in their development program backup vehicles which often, fortunately, don't have to be used, because the first one works. They don't have to fire the second one. Well, that one is available, you see.

Mr. KING. Well, now, the way it worked out in practice, why is it that the actual production of these missiles is in the hands of the defense installations and the production is not in the hands of NASA?

Dr. DRYDEN. Well, in this particular case with Douglas, there will be Douglas firing crews that do the firing. And the whole contract is with them.

As I recall, that Delta contract for 12 vehicles will cost us $3 million for modifying the Thor's, assembling all the pieces, getting it ready for firing, doing the firing, and paying Canaveral the fee.

The only place that the Air Force comes in there is, first of all, in allocating a Thor off the production line for this purpose; and, second, in placing it on the schedule at Cape Canaveral, so it doesn't interfere again.

So there are two points. Since we are using the ballistic missile booster in which the Air Force is involved, then all the money contracting in that case is done directly with Douglas.

The same way with the big engine. That is done with Rocketdyne directly from NASA.

Mr. SIEPERT. I think a convenient guiding line or definition on this would be this:

First, we have to pay our way on these boosters and payloads. This appropriation finances our total activity in that field.

Mr. MITCHELL. Let me interrupt, please.

Mr. SIEPERT. Yes, sir.

Mr. MITCHELL. I was going to ask you about whether the same was true for payload.

Mr. SIEPERT. Yes, sir.

Mr. MITCHELL. As well as for the missile itself?

Mr. SIEPERT. Yes, sir.

This appropriation finances the total cost of designing, procuring, developing, and firing the vehicle. This is all in our R. & D. appropriation.

Now,——

Mr. MITCHELL. Then, let me pursue that just a little bit further.

What do you do—I understand the procedure insofar as the missile itself is concerned and the military priority attached to them. What do you do in-house if anything insofar as payload is concerned?

Dr. DRYDEN. We do about 10 or 15 percent of the payloads in-house. The other 85 percent or so, by our universities and by people like the Space Technology Laboratories and people like Von Braun at ABMA.

Now, the reason for this is: if you are going to control a complicated program of this type, you must know something about it. You must have some people who have had experience in the field.

So, with this kind of a split, a certain amount of it is done as an in-house operation in preparing payloads. We have the people in our staff. They know good work when they see it. They can ride herd on the testing carried out by the people and can do the evaluation.

Mr. MITCHELL. But you don't have the military priority problem that you have as far as the availability of missiles, as far as the payload is concerned?

Dr. DRYDEN. No, this doesn't arise there.

Mr. MITCHELL. Now, speaking of contracts, following Mr. King's line of questioning——

Dr. DRYDEN. Yes.

Mr. MITCHELL. What about the space capsule?

Dr. DRYDEN. The space capsule was contracted with McDonnell Aircraft, by the NASA, as the result of a competition in which 12 companies submitted bids according to specifications that our people had laid down.

Mr. MITCHELL. I wanted that as an illustration that you do do contracting.

Mr. SIEPERT. Yes, sir.

Dr. DRYDEN. Yes.

Mr. MITCHELL. So far as payloads and special projects such as Project Mercury.

Dr. DRYDEN. A case that might interest you: We are using the local Navy group in this case to do auditing, monitoring from the business point of view.

Mr. SIEPERT. But not the technical side?

Dr. DRYDEN. Not the technical.

Mr. SIEPERT. I think this is an important distinction. We go through the military services in contracting, when the item that we need is an item that is essentially in the military weapon catalog. It is a part of the missile resources of the country.

When we buy this particular object, of course its production is intimately tied in with the security requirements of the country. Therefore, we must deal, we feel, through the military in arranging the schedule.

Dr. DRYDEN. This is changing—part of this rapidly changing picture.

All of our space efforts now use military ballistic missile boosters. The development cost of those is all written off in the ballistic missile development.

So, really, you would be misled as to the cost of the space program if you only considered our operating costs based on Thor and Atlas, because we didn't have to pay for the development of Thor and Atlas. The Department of Defense underwrote these development costs in its ballistic missile program.

Now, we are entering the stage with Vega and with—well, even Vega uses an Atlas, a military development, as the first stage.

When we go to the big engine that North American is developing with NASA funds, you are entering the proposition in which NASA pays the full cost of the development as well as the production cost of something already developed.

Mr. MITCHELL. What you are saying, Doctor, is that as far as the present generation of the missile is concerned, NASA has had a free ride?

Dr. DRYDEN. It had a free ride.

Mr. SIEPERT. So far.

Dr. DRYDEN. On the development costs, because the development costs have been charged to the ballistic missile program. And we are asked to reimburse only the manufacturing costs now of the item, plus the launching cost.

Mr. SIEPERT. As we develop these new items that are not in the standard military catalog, these are ones where NASA needs to use a very high quality, technical competence in its own agency. So it knows what kind of work it is about.

Mr. MITCHELL. These will be vehicles that are designed primarily for space exploration?

Mr. SIEPERT. That is right.

Mr. MITCHELL. And for no military purpose.

Mr. SIEPERT. By the same token, those contracts that go out for new items of this sort are ones that NASA is likely to contract directly with the manufacturer, so that the procurement responsibility parallels the technical line. Most of these contracts will go to the aviation

industry, the electronics industry, or major defense contractors. Here it makes good sense, we think, for us to tie into the military standard administrative procedures—the one who approves overtime expenditures and auditing of costs and that type of thing.

So we will ask for service to be performed for us at the plant by the cognizant military agency. This is about the same way as when Air Force and Army are dealing with the same contractor. One of the two of them decides on who is going to administer the contracts on the site.

Dr. DRYDEN. You see, otherwise we would have to build up very large staffs of auditors, field inspectors, resident managers, and throw another type of administration into the plant, with the resultant confusion. The contractor keeps his books only one way, which satisfies the Air Force, Navy, or whoever is in there. We are going in and using that as a service. I don't know whether we are going to have to pay for some of this or not.

We again are trying to hold our payments to cases where they have to put on more people to do our job.

Mr. MITCHELL. Anything else?

Mr. KING. Well, now, Dr. Dryden, we find today that the Army is in the business of turning out missiles. I have been down to Redstone and I saw their mass production facilities, although they are turning them over to Chrysler and others. But my question is: Why is it that we find in fact the Army in the business of turning out missiles on an assembly line basis, that we do not find the Air Force or the Navy or NASA? Is that a matter of historical accident or is it because the Army found itself with facilities that made that easier for them to accomplish?

Dr. DRYDEN. I think the answer probably ought to come from the Army. It is commonly believed to be associated with the different philosophy of the Army.

You may recall that they have a so-called arsenal system, in which they have done traditionally the development of Army weapons in-house. And only after they have developed them have they then gone out to industry to production contracts. The Air Force is operating in a different fashion.

I say perhaps you ought to ask somebody from the Army for an accurate explanation of why at Redstone they are doing as you say. They are actually making the Juno II's for us on that line down there. They have an order from us for five Juno II's which they are manufacturing in-house at Redstone.

Mr. KING. Well, in any event, the reason why NASA is not producing missiles is that the Army is already doing it and presumably doing a good job, and has the facilities, so it is just as easy to use their facilities as to set up your own facilities. Is that a correct statement?

Dr. DRYDEN. We would not want to set up facilities to make missiles. We would be inclined to use industry or in this case, since we want to use the Juno vehicle which the Army has developed, and they want to make it down there—we accept that decision of the Army.

Mr. KING. Furthermore, they have the problem of stockpiling, since they are a military installation?

Dr. DRYDEN. Yes.

Mr. KING. They are in effect building up weapons of war. NASA, being civilian, is not interested in building up a stockpile for defense purposes, but merely——

Dr. DRYDEN. Yes, sir.

Mr. KING. Using a few for experimental purposes; is that correct?

Dr. DRYDEN. NASA foresees no large production of space vehicles for its operations. We do hope to get a little more standardization than we have now, so that you can get a continuity of experience on the same vehicle, and not be always on a learning curve with some new vehicle.

But we don't believe you will ever make them by the 50's, as the DOD does for ballistic missiles. We have ordered 12 Delta's, for example. Now, whether we go much beyond that will depend on how useful it all turns out to be, and so on.

Mr. MITCHELL. You don't foresee congested traffic in space?

Dr. DRYDEN. No.

Mr. MITCHELL. In the next few years?

Dr. DRYDEN. No, I don't think so.

Mr. MITCHELL. Anything else, Mr. King?

Mr. KING. Are you in a position to estimate what the total cost of our space program has been, well, we will say in 1958, including NASA and all——

Dr. DRYDEN. Roughly $800 million, combined NASA-ARPA space budget, exclusive of ballistic missiles. If you included ballistic missiles—if you call ballistic missiles "space," you get a much larger number, of course. You get into the billions.

Mr. KING. Exclusive of ballistic missiles, $800 million?

Dr. DRYDEN. That is right.

The cost for fiscal 1959, total cost of space program, exclusive of ballistic missiles, is about $800 million. This includes Discoverer operations now going on in the military, and all of the NASA operations.

Mr. KING. Now, suppose you were to add to that all of your ICBM and IRBM programs.

Dr. DRYDEN. Well, I do not know what the numbers are. You get into several billion dollars. As I say, space has been riding. The reason the space is so small is that the development costs of Thor's and Atlases are charged to the ballistic missile program.

I don't recall what the 1960 figure is. It isn't a whole lot higher.

Do you remember the number?

Mr. ULMER. No.

Dr. DRYDEN. Ours is $485 million. The overall Government figure may be $100 million more. I don't know, because I don't know that the defense budget is finally crystallized yet.

Mr. MITCHELL. Anything else?

Mr. KING. No.

Mr. MITCHELL. Any questions?

Mr. CARSTARPHEN. I would like to get a couple of questions in, to get the record complete. These I believe can be answered very briefly.

First, the reimbursement detail item under the headquarters allotment.

Mr. ULMER. Yes. That I believe is around $18,000.

Mr. CARSTARPHEN. $18,500.

Mr. ULMER. Most of that is required for reimbursing GSA for guard service.

Now, normally, if you have a building that GSA has an opportunity to budget for in their normal course of events, guard service is provided by GSA. But during the expansion period of NASA this year we have acquired additional buildings which the GSA has been unable to budget for and we are reimbursing them for these added costs.

Mr. CARSTARPHEN. I believe grants, subsidies, and contributions is the contribution toward employees' retirement.

Mr. ULMER. Entirely. The name is just a bit unfortunate insofar as our use of the object is concerned. The full amount shown is for the Government contribution to the employees' retirement fund.

Mr. CARSTARPHEN. How about the Federal life insurance item?

Mr. ULMER. Here again, the full amount shown is the Government share of the cost of Federal employee life insurance program.

Mr. CARSTARPHEN. And I would like, please, an explanation of the refunds, awards, and indemnities.

Mr. ULMER. That relates entirely to two programs—a small program of incentive awards under the Government awards system for suggestions made by employees, and the program that permits payments for tort claims.

Mr. CARSTARPHEN. And the last one is the item for taxes and assessments.

Mr. ULMER. There are a small number of employees who are hired annually who do not have civil service status, and therefore do not contribute to the retirement fund. For those employees we are required to contribute the Government share of the social security cost. That line item covers such costs.

Mr. MITCHELL. Anything further?

Mr. CARSTARPHEN. That is all I have, Mr. Chairman.

Mr. MITCHELL. Anything further, Mr. King?

Mr. KING. No.

Mr. MITCHELL. Dr. Dryden, I thank you and each of your associates for appearing today.

Mr. KING. It has been most helpful.

Mr. MITCHELL. I commend you on your presentation.

Dr. DRYDEN. We thank you for giving as much time to it as you are giving.

Mr. KING. It has been very helpful.

(Whereupon, at 4:10 p.m., the subcommittee adjourned.)

1960 NASA AUTHORIZATION

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON SPACE PROBLEMS, AND LIFE SCIENCES,
SUBCOMMITTEE NO. 4,
Washington, D.C., Friday, April 24, 1959.

The subcommittee met, pursuant to notice, at 10:22 a.m., in room B-214, New House Office Building, Hon. B. F. Sisk (chairman of the subcommittee) presiding.

Mr. SISK. The subcommittee will come to order.

We have with us this morning some people from NASA, Dr. Dryden, Dr. Silverstein, and some backup people. We want to proceed to a line-by-line consideration of that portion of the budget which has been assigned to subcommittee No. 4 for consideration. That will deal with the four principal subheadings under research and development, those four being space propulsion technology, space systems technology, supporting activities, and vehicle development.

To start with this morning, I have already discussed—I might say to my colleague from California here—a suggestion that Dr. Dryden be asked to outline very briefly for the committee the procedure used in arriving at the specific figures in the request—that is, starting with who initiated the figures, how those figures were arrived at, for example, why it was $2 million instead of $5 million or vice versa, and then to whom they were submitted; that is, the channels through which those figures went before they were finalized in the budget as a request.

If you would do that briefly for us this morning, we will start with that. Then we will move to the line-to-line consideration.

Dr. DRYDEN. I will try to recall as well as I can the sequence of events. You recall that NASA was not in existence until October 1.

The budget had to be submitted, I believe, by September 15. The NACA then in existence had been instructed to prepare the estimates for NASA. You may recall my appearing before the committee on the original additional appropriations in addition to those that had already passed the last Congress for NACA.

On the basis of such planning as we had done at that time we submitted, to comply with the Budget Director's request, a line estimate, as I recall it, of $623 million as what we would be asking for.

Dr. Glennan was sworn in during August. The first day he was on the job we presented him with this letter to sign. He of course had no time really to review the thinking back of this figure. Subsequent to transmitting this letter, we did discuss our program with ARPA, not specifically from the dollar point of view but from the subject point of view. We again had been directed by the President——

Mr. MCDONOUGH. You are speaking of the total amount at that time?

Dr. DRYDEN. Yes, the total amount at that time. We again had been directed by the President to consult with the Department of Defense on the programs, and in discussing the programs—not dollar figures but what we were going to do with regard to ARPA—it was obvious there were some duplications. I do not remember at the moment at whose initiative, but a meeting was set up between Deputy Secretary of Defense Quarles, Mr. Roy Johnson, perhaps one more member of his staff, Dr. Glennan, myself, and Abe Silverstein with Dr. Killian presiding at the meeting to discuss these duplications.

As an example, both of us had budgeted for the clustered engine now under development. We both carried figures in our budget for that same development. It was obvious we shouldn't come before the Congress in two budgets asking for the same thing.

The result of that review was to reduce this $623 million we had been talking about by some $100 million. I will be glad to put a more accurate statement in the record. I am depending on my memory now. The mere duplications which were obvious at first glance removed about $100 million from the $623 million we had in.

There were some other aspects of it to be discussed. We proceeded to discuss the space program as a whole. I don't know that I can give you the detail of this, but the net result, the first detailed submission of a detailed budget to the Bureau of the Budget was for $485,300,000 that you have here. I would like to make very clear that at no point was a ceiling imposed. There was no preset figure.

There were discussions of the program. We maintained the point of view in all these discussions that we maintained the year before with the old committee that if things changed and we thought we needed more money, we would come back through channels for it.

So the $485 million was the compilation of estimates for a program based on a flight schedule of certain developments we have been telling you about in the space science program. The numbers came from consultation with people in the Department of Defense on the costs of rocket development, for example. In the space science area we had some of the costs involved in the IGY space science loads, and in some cases we did ask a number of contractors about rough estimates of costs of doing various operations.

That in brief is the way in which these figures were arrived at.

Mr. SISK. Thank you, Dr. Dryden. I think that generally gives the information that I had in mind for purposes of the record. Does the gentleman from California have any questions he would like to direct to Dr. Dryden before Dr. Silverstein takes over?

Mr. MCDONOUGH. The amount you estimated for the first operation of NASA, that is up to June 30 of this year?

Dr. DRYDEN. The $623 million was the estimate in September of the amount through 1960. Out of these discussions came also of course the submission of the 1959 supplemental which you have heard and already passed.

Mr. MCDONOUGH. In other words, the $485,300,000 that we have here is not any carryover of the previous. That is the amount you will need for fiscal 1960?

Dr. DRYDEN. No. The supplemental is roughly the amount that the Congress cut out of our submission last year, but this is somewhat accidental. It is not the identical items.

Mr. SISK. In order to tie it to the four specific items with which we are concerned, the four subheads, actually was there any supplemental above and beyond the original appropriation which was made for fiscal 1959, dealing with those four items? It is my understanding there has not been. Is that correct or not? That is space technology, space systems, supporting activity and the vehicle development.

Mr. MCDONOUGH. On page 201.

Dr. SILVERSTEIN. In that framework of items the supplemental 1959 has no items.

Dr. DRYDEN. You are correct.

Mr. MCDONOUGH. Including tracking——

Dr. SILVERSTEIN. There were tracking funds, but those were in C. & E. They were in another category.

Dr. DRYDEN. The other item is in the other subcommittee's area, space operations technology.

Mr. SISK. I was going to suggest there is a $20,750,000 figure which happens to fall under the other subcommittee, under space operations technology. I think what we would like to do is deal specifically with the four subheads in view of the fact that is under our subcommittee's jurisdiction.

Mr. MCDONOUGH. As I understand it, Mr. Chairman, the $485 million in the bill before us is the amount that is within the President's budget and approved by the Bureau of the Budget.

Dr. DRYDEN. That is correct.

Mr. MCDONOUGH. Your estimate in this book doesn't exceed that?

Dr. SILVERSTEIN. The estimates are equal to it.

Dr. DRYDEN. It is the support for that figure.

Mr. MCDONOUGH. Then, as the chairman indicated, what you want to do is to get the detail and background as to why you want, we will say, for instance, item 1, that we are considering; why do you want $3 million for solid-propellant rockets; and on down the line. That is the way we want to study it.

Mr. SISK. Does counsel have a question?

Mr. WILCOVE. Dr. Dryden, it would appear that the Budget Bureau approved the entire amount requested by your agency. Is that correct?

Dr. DRYDEN. I think I have to repeat the history. We submitted on September 15 as they required, a preliminary figure without any backup whatever, just a letter saying "Our present estimate is this. We are a new agency. We are just in the process of formation. We will have to wait until later to supply you with the detail."

Before the detail was sent in we had the discussions to which I referred. So the official request after NASA was in existence, by Dr. Glennan was $485,300,000, and this was not changed by the Budget Bureau.

Mr. WILCOVE. So you really reached sort of an agreement before you submitted your official figures?

Dr. DRYDEN. The Budget Bureau was not involved in the particular discussion I mentioned. This was a discussion under the offices of the President of the programs between ARPA and NASA.

Mr. SISK. Unless there are further questions, then we will proceed to an item-by-item consideration. Dr. Silverstein, we are very happy to have you with us this morning to give us some enlightenment on

these figures. So under space propulsion technology, our first item then is solid propellant rockets. As I understand, it is explained in a little further detail on page 262. First, if you would make any comments you have explaining the amount already expended in 1959 or that will be expended or obligated or if there are any unobligated balances, I think that would be a good procedure in each one of these items. Mention at least the amount of expenditures.

For example, in this case there is $700,000 apparently in your 1959 budget. If there are any unexpended or unobligated balances, would you note that as we proceed?

Dr. SILVERSTEIN. Yes, we can do that. We have the figures here. I will discuss very briefly the subject area here. I think you are well aware that solid fuel rockets play a very important part in the whole technology of missiles and space vehicles. There have been in the past few years rather marked technological gains in this field. These have come as a result of development of new propellants, and new hardware for these rockets.

This progress has shown itself in this way. One of the important descriptive terms which we use to define rocket propulsion systems is called the mass ratio. That is the ratio of the mass of propellant carried in the rocket to the total weight of the whole unit. You want the highest value of the mass ratio you can get.

A few years ago values of .85 were considered very good for solid rockets. As a result of some technical gains such as: new materials for the rocket cases, new methods for design of the downstream nozzles of the rocket, we have been able to push the mass ratio up to current values of .88 and .91. We are interested in high values of this mass ratio. I think you can appreciate very quickly that if you have more propellant aboard and less dead weight, you can, therefore, produce a higher velocity out of this piece of equipment you are carrying.

Solid propellant rockets remain stable and ready to fire for long periods of time.

This turns out to be extremely important when you are trying to go long distances. We are visualizing currently that solid rockets will play a very important part in the space program, in particular for the last stages of some of these vehicles that have to go out into space. They will be required to stay out there for long periods of time. For example, on a Mars mission, the current figures are it would take 235 days to travel to Mars. During that time you want the last stage, which will be used to orbit a payload around Mars, to be very stable and to have a high efficiency. So we are trying to develop the components for this advanced system technology by expending funds in the area of solid propellant rockets.

There are good possibilities here, excellent possibilities.

You will recall that—do we have a closed session here essentially?

Mr. SISK. Actually no, and I am sorry, Dr. Silverstein, I did not make this clear to start with. At least it was the chairman's hope that initially on these discussions that this be an open session. On such matters as members may desire to have information or to question, we will hold those until, let's say, Monday, or some time in the future. I am sure, Dr. Silverstein, there are going to be some questions, particularly on vehicle development, including Vega and Centaur, which

I am relatively sure you will probably want to discuss in closed session.

I am hopeful that Mr. Riehlman and Mr. Hall will be able to be with us at that time so we might have the full subcommittee present then.

If you could this morning consider this as an open session, at least the Chair would prefer it. I would be glad to hear from my colleagues on that at the moment, if you desire otherwise. In view of the fact that these meetings were called rather abruptly, as you probably know, and the fact that due to previous commitments two of our members cannot be here, we would like to proceed on that order today.

Dr. SILVERSTEIN. Fine, Mr. Chairman, I will redirect my statement here a bit.

We have shown for 1960 in this line item, $3 million broken down, as shown on page 263 of your book here, into "Scientific and technical studies." In this area we do the advanced research required for the development of these units. As you will see in terms of the sum of money required here, this is not a great deal of money for advanced development. Other work is going on of which we are aware and with which we are in close contact. We have tried to avoid duplicating this work. This work is aimed very specifically at some of the needs we see for the future.

The "Prototype and operational hardware" item carries the research effort required for the solid rockets of advanced types. It includes funds for providing hardware that can be used for testing to bring it to the point where you can actually count on using these rockets at a later time in actual development units.

Another important area included here is that of the thrust modulation and thrust vectoring. A solid rocket, as you know, when you turn it on keeps running until it burns all its fuel. If during the period of its operation, you could change the thrust, you could cut down the high accelerations that are currently experienced in the latter stages of missile systems, rockets, and space vehicles. We are working in that direction.

Mr. MCDONOUGH. You mean the change of rate of combustion is something you are experimenting with?

Dr. SILVERSTEIN. Yes.

Mr. MCDONOUGH. This is new, of course, because I noticed in 1959 you had nothing for the modulation and thrust vectoring system.

Dr. SILVERSTEIN. That's correct.

Mr. MCDONOUGH. It is all new in 1960. In other words, this is laboratory testing, I suppose.

Dr. SILVERSTEIN. Yes, it is, sir. The problem is this. If you have a rocket that, let's say, is the last stage of a vehicle, and when it starts to burn, the rocket is accelerating not only the payload but also the loaded weight of the rocket. The weight of the loaded rocket may be a substantial part of the total weight. By the time it finishes burning, the weight that is being accelerated is now very much smaller so that the payload now is accelerated at a very high rate, sometimes as high as 10 to 20 times the value of 1 G, which is the acceleration the earth applies to our bodies.

This means we put stringent requirements on guidance systems that have to be in the last stages of these rockets. We have very sensitive

equipment here in the way of gyro systems that are disturbed if they have to operate in a high accelerating force. We are trying to reduce these forces by reducing the rate of burning toward the end of the burning process. This is an advancement, part of the technical development of the field.

We had $700,000 this year, and we have the record here of the expenditures to date.

Mr. HYATT. The expenditures to date are roughly $0.4 million, or $400,000, and we have commitments to the tune of $230,000.

Mr. SISK. So actually you have about $70,000 unobligated at the moment?

Mr. HYATT. Uncommitted, because some of the other is obligated—$70,000 uncommitted or unobligated.

Dr. SILVERSTEIN. That is, 10 percent of the fiscal 1959 funds is, as yet, uncommitted.

Mr. SISK. Are there any other questions then with reference to the program on solid rockets?

Mr. ROUSH. I had a couple of questions. I was wondering how much you asked for originally, Dr. Silverstein?

Dr. SILVERSTEIN. In this area?

Mr. ROUSH. Yes, sir.

Dr. SILVERSTEIN. I don't have these numbers. I can try to put them in the record. Were you here in our initial discussions——

Mr. SISK. Would my colleague yield for just a moment?

Mr. ROUSH. Yes.

Mr. SISK. We had with us Dr. Dryden—I believe he is gone now. We opened with a discussion as to their original request—that is, by the NASA people themselves, the scientists and heads of the agency—as compared to what Budget approved. The statement by Dr. Dryden was that the Budget did not cut a penny from their request.

As I understand—and you can correct me, Dr. Silverstein, or my colleague, Mr. McDonough, if he understood otherwise—the budget submitted and the items in the budget were not changed by the Bureau of the Budget.

Is that substantially correct?

Dr. SILVERSTEIN. Exactly correct with reference to the detailed submission we made to the Bureau of the Budget.

Mr. ROUSH. I am sorry I was late, Mr. Chairman.

Mr. SISK. I appreciate the problems involved. I did want to mention that—that that was the initial question asked of Dr. Dryden so that we could, for purposes of the record, have a clear understanding as to whether the agency had originally felt it needed substantially more money, or whether going through channels had reduced or changed the total of the budget.

Mr. MCDONOUGH. Mr. Chairman, just one other question. On your present obligations is the majority of that in supplies, equipment, repairs and alterations? In what category are your present obligations?

Mr. HYATT. No, sir. The principal obligations are in the actual experimental work—the design, analysis, and conducting of the experiments.

Mr. MCDONOUGH. Is that contracted out?

Mr. HYATT. Yes, most of it is contracted.

Mr. McDONOUGH. It is being done by outside laboratories?

Mr. HYATT. Yes, sir.

Mr. McDONOUGH. Not in-house operation?

Dr. SILVERSTEIN. Almost wholly outside NASA in this case.

Mr. McDONOUGH. And the $70,000 balance that is not committed will be unused, that is not included in the $3 million that you carry over to the next year?

Dr. SILVERSTEIN. It will be used, sir. We still have several months and we have many projects that we could support and wish to support in this area. We simply don't have more than these funds left to support them. This is an area of great interest to industry. We have been bombarded with proposals for new ideas which they would like us to support. We have ample opportunity to support them with funds. We are studying these proposals. We most certainly will utilize our funds during the rest of the year.

Mr. McDONOUGH. On that question, Mr. Chairman, industry, of course, is very ambitious and aggressive. I mean out of the in-house operation—your contracted laboratories. How many proposals do you take on before you complete the first one you took on? That is a kind of a hard question to answer, I know. How many new proposals do you accept from industry that look good and keep building up new proposals without completing the first one?

From my experience it occurs to me that if in the first instance you accepted a proposal from industry, you may find in the progress of that experimentation, things that you don't have to contract for the second time. But, if you don't allow the thing to go to its ultimate end, you are contracting and duplicating before you get through.

Dr. SILVERSTEIN. We have built up a staff in this area whose purpose it is to insure that our contracting does make sense all the way. We try to avoid this duplication. I hope we are doing it. I hope we are doing a good job in this area.

We have well qualified people who know this field very thoroughly. The man who is heading up this area of solid rockets, for example, is one of the most experienced men in the country in this area, and knows the field thoroughly and has been working in it for many years. We hired him especially for this job.

He is monitored also by Mr. Hyatt, who heads up the whole propulsion area and also in my office. We are both familiar with this field because I have been in the propulsion business myself and have watched it for some 15 years. Before that I was watching the aerodynamics field.

The point is, we feel the responsibility of spending this money very keenly and are trying desperately to do the best job we can to make sure that these kinds of duplications don't exist.

Mr. McDONOUGH. While you are doing that and carrying out and contracting for proposals that are submitted to you, what is the Defense Department through ARPA doing? They are going along the same lines, aren't they, to a certain extent?

Dr. SILVERSTEIN. In the solid rocket field they have a program we are well aware of. We know exactly the content of their program and our program is somewhat different than theirs. Their program in ARPA is aimed almost wholly at new chemical discoveries, chemical combinations, that might yield higher thrusts.

Our program is aimed more in the direction of accomplishing specific rocket developments for use in the space field, more in the hardware area than in the chemical area. Only a small piece of it is in the chemical area to tie our chemistry to the hardware.

Mr. McDonough. There is an exchange of information from one to the other?

Dr. Silverstein. The man who is heading our solid rocket program worked on the committee that set up their work. He was a member of that committee. We have a very close tie here.

Mr. Sisk. Any other questions?

Does counsel have any questions?

Mr. Wilcove. No.

Mr. Sisk. I recall very well the presentation made to the full committee also on this. I think it showed substantial needs in this field.

We will move on then to the high energy propellant rockets, where in fiscal 1959 I believe you had $7 million and you are now asking for $65 million. Please explain the figures and the basis again of how much of that has been committed and so on.

Dr. Silverstein. Pardon me, did you say $65 million or is it $5 million?

Mr. Sisk. In 1960 fiscal year you are asking for $5 million, whereas in 1959 you apparently had $7 million. This is in one case where apparently you are asking for less in the coming year than you had this year.

Dr. Silverstein. I will be glad to explain that.

Mr. Sisk. Fine.

Dr. Silverstein. As for the item for $5 million on high energy propellant rockets, we are trying, in keeping with what we believe are the lines and directions established by both the President and Congress, to provide a forward-looking program. I don't believe that any of us want to stay in this business in second place. We see the things ahead that need to be done, and are taking steps, in what I consider to be a relatively small way, however, to get at the basic research and development that is needed to move the field of high energy propellants along.

High energy propellants are extremely important in the advanced space missions. I think it was described briefly for you in the charts we presented during the full committee hearings. The upper stages of space vehicles should be high energy propellant stages because they greatly increase the capability for the vehicle to accomplish its mission. Let me give you an example.

We show you for example within this item sums of money of $1.7 million for fluorine-hydrogen rockets, and another sum of $1.7 million for hydrogen-oxygen rockets. You may recall that Mr. Rothrock in his initial testimony showed you the great importance of this term we call specific impulse, or pounds of thrust which you get per pound of fuel burned.

With hydrogen, the value of specific impulse is something like 30 to 40 percent higher than it is with the conventional liquid oxygen-kerosene propellants that we are using in our current missiles and in our early space vehicles.

It turns out that when you are trying to carry a load into deep space that this larger specific impulse may increase your load-carry-

ing capability by as much as four to five times for some missions. This is the reason that we are interested in pushing ahead with these fields.

One fuel combination is of particular interest—that is, the combination of hydrogen as a fuel and fluorine as an oxidizer. This produces a specific impulse of around 435. It is the highest impulse of any combination of known rocket fuels with the possible exception of using ozone as the oxidizer in place of fluorine.

In this field, of course, the chemistry of propellants is well known. The chart of atomic materials is well established. We know the limits of the things that we can use. So we have moved toward the top of the range of these things to get our ultimate developments.

We are doing a bit of work in ozone. It doesn't look very attractive. We have been working some in fluorine at NASA research centers and are now carrying on a contractual program in this area with the Bell Aircraft Co. This program is an extension of the work that was started earlier by the Air Force. When NASA became established as an agency, this work came into our hands and we are continuing it. It is a program that is moving along quite nicely. We are working with actual hardware. This type of advanced R. & D. is the kind that is needed to give us greater capability for the future.

In the same way, we show a line item here of $1.7 million for hydrogen-oxygen. You will recall in our charts in which we discussed some of our advanced systems we showed high energy stages that require thrusts in the order of 80,000 to 100,000 pounds. I don't know whether you recall the Nova vehicle study that we showed. I can put the chart on if you would like to see it. I brought them along for that purpose.

Mr. SISK. I might say the Chair recalls they made a very good presentation on this. If any member of the committee would like to have the charts, we will have them shown; otherwise we will proceed without them.

Proceed, Dr. Silverstein.

Dr. SILVERSTEIN. We are going to contract again in this area to do work which will lead to the development of engines having a capability of 50,000 to 100,000 pounds of thrust. These numbers are well-established as budget numbers in the sense that we have already determined the kind of a program and its costs for the year ahead. These are not really estimates in the truest sense. They are fairly well determined.

Mr. MCDONOUGH. I notice in your prototype of operational hardware you have a $2 million item there for oxygen-hydrogen fuels which you have abandoned, evidently.

Dr. SILVERSTEIN. No. This program is not abandoned. It is a program made up of two parts. A substantial part of this we initiated at the Lewis Research Center as an in-house program. The program is coming along very nicely. It is leading toward the development of the fuel system and the tankage. With hydrogen as the fuel, there are some new problems introduced. You see, hydrogen is a fuel that evaporates from liquid to the gaseous state at about minus 400° F. That is cold, and you can very well see that in handling this fuel, in a propellent tankage, and in the lines to carry the propellent from the tank to the engine we introduce many new problems.

There are insulation problems. We have this thermos bottle concept that was introduced in the hearings the other day, plus the fact that measuring the flow rates of fuels like this require entirely new technologies. You can't use conventional flow meters without major changes in their characteristics.

Lubrication in a pump, for example, in the type of bearings that operate at minus 435° F. is in itself a new problem. These problems haven't been tackled before. They are brand new to the technology. These are the kinds of things we have had to carry on in-house until we could bring the technology to a level at which we could adequately contract outside with enough background to the work so it can be carried on satisfactorily.

In the coming year we are not showing any effort here because now we are getting to the point where we feel we can carry this work on adequately by contract.

Mr. SISK. Proceeding then to that last item there, where in 1959 you had $3 million. You are down to $1,600,000 in your request for 1960. Is that a similar situation?

Dr. SILVERSTEIN. A smilar situation exactly. We have been carrying along this work. Now we are actually going into development in the third stage of the Vega vehicle. We are putting in an engine with this characteristic and actually going into a development phase. Therefore, we can reduce now some of the advanced work, because it has progressed to the point where we can actually move into development. There are still some problems left over which we are going to pick up with these funds, but we are able to reduce the funds.

Mr. SISK. Are there any further questions regarding the high energy propellant rockets?

Let the Chair go back for just a moment here so we can develop suitable procedure. Unless there is objection as we move along item by item here, unless there is, let's say controversy or difference of opinion, the Chair would like to consider these items as approved by the subcommittee for purposes of our recommendation. As I understand that is the only power we have, to recommend to the full committee.

So, without objection, the item of $3 million on solid fuel rockets will be considered as having our approval.

Without objection, the $5 million on the high energy propellant rockets will be considered as having our approval.

Hearing no objection, then, it is so ordered.

We will proceed, then, to the next item having to do with the 1 million pound thrust single-chamber engine, for which, I believe, you are asking, Dr. Silverstein, for $30,200,000. In 1959 I believe you were given a $10 million appropriation.

Dr. SILVERSTEIN. Yes, sir.

Mr. SISK. I think first it might be well if you would explain what has happened to the $10 million or to what extent that is committed and so on.

Dr. SILVERSTEIN. In regard to the million pound rocket engine, I might say historically, for the last several years various technical committees have met, comprised of the technicians in this country who are well-qualified in the rocket field. Unanimously—and I am aware of at least four major reports in this area—recommendations were

made that, for the advanced capability of this country looking toward space, it was absolutely essentially that we move into the area of constructing a million pound rocket. There has been no single group who has disagreed with this philosophy.

When NASA was formed we established a propulsion group in combination with the Department of Defense to discuss the many propulsion items in the program, and most of the items I have discussed so far were taken up in this group.

Again it was the unanimous opinion that this million pound rocket was perhaps the most important element for providing us the increased capability for the future. You see, in our current national program, our most serious shortcoming is in our booster capability. This is the place where currently we are in the greatest trouble.

I feel this is an area in which we will always be in the greatest difficulty unless we take the step of building this advanced capability or starting it now so as to acquire capability for the future. Rocket engines of this size take long times to develop. As most of you are familiar, from other contracts you have made in this area, normally 5 years are required to develop a good turbine engine. History tells us it is taking about 5 years to develop a good rocket engine.

We have to look that far ahead in order to be sure we are providing the country with the capability it needs.

So last year, we initiated a contract. First we wrote a specification. Then we circularized it to the seven major engine companies in the country. They bid on this specification. We selected a contractor after going through the usual processes of evaluation. The contractor was the Rocketdyne Co., a division of North American Aviation, Inc.

We let a contract for $102 million for the development of this engine over a period of about 4 years. The contract was started during this fiscal year. Initial payment to get this work under way was $10 million, as shown in our budget for 1959. The contractor's estimates for the work he is to do during the current year amount to this $30,200,000 which we are asking for in this budget.

This number is a firm number, based on the greater progress expected during the year.

Mr. SISK. Dr. Silverstein, as I understand, then, the contract was let for $102 million for this large rocket engine.

Dr. SILVERSTEIN. Yes, sir.

Mr. SISK. In 1959 you actually made an initial payment to Rocketdyne for the $10 million. That was for initial phases of their work.

Dr. SILVERSTEIN. Yes.

Mr. SISK. Assuming that they are given an additional $30,200,000 in 1960, that will bring, then, to $40,200,000 the total which they will have received.

At this time what do you anticipate, based on their progress at the moment, might be your position a year from now with reference to that? I understand originally you had in mind a 4-year program.

Dr. SILVERSTEIN. Yes, sir.

Mr. SISK. Is there any indication that that time may be shortened? To what extent do you feel progress is involved?

Dr. SILVERSTEIN. Their current progress is very good. I think you saw in the movie that Dr. Dryden showed in the open hearing to the whole committee pictures of the first tests of an uncooled combustion

chamber, which is a first step in the development of these large rockets. The work is moving along currently quite well. We are running into the usual problems that you encounter in the development of an engine. There was a failure shown on that film, which is the kind of a failure that we encounter quite often in initial development.

It is too early, I believe, to know how serious the problems are going to be. The history of all engine developments has been about the same. If you recall, this engine stands three man-heights. The fabrication problems here are truly enormous. We have all these passages that carry the coolant down this long nozzle. They have to traverse this whole length and enter into the injection head and then have to be spread to the injecton head uniformly so that there are no hot spots in the head.

These engineering problems and technological problems are very difficult, and frankly I don't know whether we will be able to go any faster in the program. I hope we will. We are monitoring the program quite closely with excellent technical people, and if there is a way of helping to make it go faster, we will do it.

I can't really add much to that.

Mr. SISK. I might say, Dr. Silverstein, this is the third largest single item in our portion of the budget under discussion here this morning. I realize the problems involved in any breakdown of these figures. Of course, as I see it, we really have no breakdown because it is a contractual relationship with Rocketdyne.

Do the other members of the committee have questions?

Mr. ROUSH. Mr. Chairman, I have some questions.

Mr. SISK. The gentleman from Indiana, Mr. Roush.

Mr. ROUSH. Do I understand, Doctor, that this contract calls for the development of one engine—in other words, they are going to design and fabricate an engine from which we might go into production, is that correct?

Dr. SILVERSTEIN. Yes, this is a development contract, and it will include more than a single engine. In the process of developing an engine like this, there have to be a number of pieces of hardware to put upon the test stand. In many cases they will fail halfway through so you build more hardware than one engine. But you end up with necessarily the complete design development so you can go into production on articles.

Mr. ROUSH. But the contract does not call for production.

Dr. SILVERSTEIN. It does not call for production.

Mr. ROUSH. Then I had a couple of other questions. One of them pertains to patent rights on new discoveries. Who holds these patent rights, if there should be new discoveries during the course of designing this engine? Does the company have the entire rights to new discoveries?

Dr. SILVERSTEIN. No, sir, Mr. Roush. In the actual bill that established NASA, there is a patent clause. This patent clause assigns to the United States the rights of patent with a statement that the Administrator may within a certain framework waive these rights if it is in the interest of the Government.

Mr. ROUSH. Do you do that?

Dr. SILVERSTEIN. We have established certain methods for handling this patent work. I think Mr. Nunn here can discuss it—he is in our legal department—if you care to have a development of the subject.

Mr. ROUSH. Not particularly here, Mr. Chairman, but I do think it would be wise to have that on hand.

Mr. SISK. If the gentleman will yield. Of course, in our original act, as Dr. Silverstein has indicated, we did put in a section dealing with patent rights. In its essential details, as I understand it, the law provided that for these contracts and for projects financed by the Government, that is essence the rights to those patents actually are in the Government. The Government holds them.

There was the provision which he indicated wherein the Administrator of NASA could, under certain rules and procedure, make patents available to private concerns.

I might say, because it has come up and it would be of interest to me, could you briefly outline your procedures on patents. That is, if you have some basis on which you would proceed to turn them over, let's say, to Rocketdyne or to some other company.

Mr. NUNN. What I would prefer to do, Mr. Chairman, is to give you a prepared statement on this. I have not prepared anything. But let me explain very briefly that there is a clause, which is in the Rocketdyne and other NASA contracts, which calls for the contractor to report to NASA any and all inventions that are thought to be made, or inventions that are made, in connection with the work being performed.

Those reports are then processed by our patent attorneys. They ascertain whether or not there is an invention involved. They ascertain furthermore the circumstances under which the invention was made. Their findings lead to the determinations having to do with ownership and waiver. With that as a beginning, that is, obtaining information, then the decisions and determinations that are to be made under the statute follow—the title determinations, the waiver determination, and the licensing determination, that is licensing back to the contractor so that he can use the invention, et cetera.

That is the procedural structure. It is predicated upon a clause in the contract which describes what procedures the parties must go through.

I would be happy to have a more complete statement submitted if you would like.

Mr. SISK. I might say to my colleague that this particular section of the bill—and I am sure my colleague from California, Mr. McDonough, will agree with me on this because he was also on the Select Committee on Astronautics and Space Exploration—gave us a considerable amount of trouble.

We spent a great deal of time and effort in the dicussions on the original enabling act which set up NASA to provide for what we felt would be the fullest protection to the taxpayers of the country for patents, inventions and so on that might come about because of Government contracts.

We established a special subcommittee on patents and spent considerable time in discussion with various groups.

I might say, quite frankly, as I understand it, some of our private companies are not wholly satisfied yet with the patent provisions in the Space Act. But on the other hand, there was a very sincere attempt made to protect the interests of the taxpayers of America in matters financed at public expense.

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I think it might be well that we have a statement.

Mr. ROUSH. I do too, Mr. Chairman.

Mr. NUNN. The entire effort we have made is to implement the very objectives that you have outlined. I will submit a statement.

(The statement referred to is as follows:)

NASA PATENT PROCEDURES

Section 305 of the National Aeronautics and Space Act of 1958 deals with the subject of property rights in inventions. The following comments summarize the major parts of that section, review the principal steps taken by NASA to implement it, and describe the main procedures developed under it with respect to contractors and the U.S. Patent Office.

THE STATUTE

Subsection 305(a) of the act provides that inventions made in the performance of work under NASA contracts shall be the exclusive property of the United States whenever the Administrator makes certain statutory determinations concerning the conditions under which the invention was made, unless the Administrator, under regulations prescribed by him, waives all or any part of the rights of the United States to such inventions.

Subsection 305(f) of the act provides that the waiver of rights of the United States to an invention under a NASA contract may be made upon such terms and under such conditions as the Administrator shall determine to be required for the protection of the interests of the United States, and shall be subject to the reservation by the Administrator of an irrevocable, nonexclusive, nontransferable, royalty-free license for the practice of such invention throughout the world by or on behalf of the United States or any foreign government pursuant to any treaty or agreement with the United States.

Subsection 305(b) of the act requires that NASA contracts contain effective provisions under which a contractor shall furnish promptly to the Administrator a written report containing full and complete technical information concerning any invention, discovery, improvement, or innovation which may be made in the performance of work under the contract.

Subsection 305(c) of the act provides that no patent may be issued to any applicant other than the Administrator for any invention which appears to the Commissioner of Patents to have significant utility in the conduct of aeronautical and space activities unless the applicant files with the Commissioner within a specified period of time a sworn statement setting forth the full facts concerning the circumstances under which the invention was made and stating the relationship (if any) of such invention to the performance of any work under any contract of NASA. The Commissioner of Patents is required to transmit to NASA copies of each such statement and the patent application to which it relates.

The next two subsections follow logically from the provisions of subsection (c). Subsection (d) provides that, upon any application as to which a sworn statement has been transmitted to NASA, the Commissioner may, if the invention is patentable, issue a patent to the applicant unless the Administrator of NASA, within 90 days after receipt of the application and statement, requests that such patent be issued to him on behalf of the United States. Subsection (e) provides that, whenever any patent has been issued to any applicant in conformity with subsection (d) and the Administrator thereafter has reason to believe that the applicant's statement contained any false representation of a material fact, the Administrator may initiate a procedure, within 5 years after the date of issuance of the patent, for the transfer of title to the Administrator.

The foregoing are the major provisions of section 305 dealing with property rights in inventions.

IMPLEMENTATION OF THE STATUTE

NASA is firmly dedicated to the task of implementing the patent provisions of the act in an objective manner and providing a fair and reasonable administration of these provisions with due regard for both the interests of the United States and the interests of private parties affected thereby.

The task of making the patent provisions of the act workable has been approached as a problem requiring both sound legal analysis of the provisions of

the act and the practical advice and assistance of industry representatives and of the American patent bar. The advice and assistance generously rendered to date has been invaluable in the formulation of policies and procedures.

The job of implementing the act, pursuant to the direction of the Administrator, has been undertaken by the General Counsel.

The first step taken was to draft a property rights in inventions clause for use in NASA contracts and to make internal administrative arrangements for the proper use of the clause. At the same time, the clause was widely circulated to industry and to the patent bar for comment. The final revision, which was recently accomplished, benefited considerably by suggestions received from the public. At the present time, further revisions are not contemplated, and this step, therefore, appears to have been completed.

Second, while the clause was being developed, the drafting of the regulations dealing with the waiver of rights in inventions was undertaken. These regulations, based on subsection 305(f) of the act, define the Administration's policy concerning (1) the class of inventions for which waiver of U.S. rights generally will not be made, (2) the classes of inventions for which waiver of rights ordinarily will be made, and (3) the extent of those rights which the Government will waive, together with the conditions, if any, imposed on the waiver. These regulations were published as interim regulations on March 5, 1959, in the Federal Register. This publication also carried an invitation to the public to submit written comments to the General Counsel and gave notice of the holding of a public hearing on May 18, 1959, at 9:30 a.m., in the NASA auditorium at 1520 H Street, NW., Washington, D.C.

The third step was the drafting of patent procurement regulations. This has just recently been completed and forwarded to the Federal Register for promulgation on May 5, 1959. Copies have been circulated to industry and the patent bar, and their comments have been invited.

Copies of the clause, the waiver regulations and the patent procurement regulations are attached hereto as items I, II, and III, respectively.

PROCEDURES UNDER THE STATUTE

The principal procedures adopted by NASA to implement the act relate mainly to relationships with contractors and with the Patent Office. At no point does section 305 purport to apply to inventions made by Government employees. Accordingly, the position taken is that such inventions are subject to the provisions of Executive Order 10096. Hence, no procedures are necessary for this purpose under section 305 of the act.

With regard to contractors, each contract entered into by the Administrator with any party for the performance of any work is required by subsection (b) to contain effective provisions under which such party shall furnish promptly to the Administrator a written report containing full and complete technical information concerning any invention, discovery, improvement, or innovation which may be made in the performance of any such work. To implement this subsection, as stated above, a clause entitled "Property Rights in Inventions" was carefully drafted for use in NASA contracts. The language of the clause is very broad, as is the language of the statute. However, by regulation a rule of reason has been adopted in the reporting situation, and a contractor is not required to report every trifling discovery, improvement, or innovation that may be made under a NASA contract. The requirement is to report those discoveries, improvements, and innovations which appear to fall within a statutory class of patentable subject matter and which have a reasonable probability of being patentable. The contractor is, of course, obliged to furnish any relevant information requested whether it appears trifling or not.

It is necessary to determine which NASA contracts must contain the clause. The plain meaning of subsection (b) indicates that a NASA contract must involve the performance of work if the clause is to be required. It also appears from a careful reading of the language of subsections (a) and (b) that contracts which involve, for example, no more than the delivery of off-the-shelf commercial items by the contractor to the Government do not involve the performance of any work within the meaning of the term. If Congress had intended to cover every single contract entered into by the administration regardless of its character, it could easily have said so. Accordingly, NASA has adopted the principle that the sort of work intended to be covered by this subsection is work of a technical, scientific, or engineering type. To express

the principle more fully, NASA will not use the "Property Rights in Inventions" clause in every NASA contract but only in those which entail technical, scientific, or engineering work of a kind performed in a contract having as one of its purposes (1) the conduct of basic or applied research, (2) the design or development, or manufacture for the first time, of any machine, article of manufacture, or composition of matter to satisfy NASA specifications or special requirements, (3) the development of any process or technique for attaining a NASA objective not readily attainable through the practice of a previously developed process or technique, or (4) the testing or experimenting with any machine, article of manufacture, composition or matter, process, or technique to determine whether the same is suitable or could be made suitable for a NASA objective.

Another aspect of this problem concerns contracts made on behalf of NASA by other agencies of Government. A literal interpretation of the statute might rule out the use of the clause in such contracts. However, such a result would not appear to be in accord with the intent of Congress. Hence, it is NASA's view that the NASA patent clause sould be included in contracts entered into by other agencies on behalf of NASA and that this should be done upon the same conditions as in the case of a NASA contract.

The foregoing positions taken by NASA are designed to protect the interests of the United States and to take into account the interests of private parties doing business with NASA.

With regard to the Patent Office, subsection (c) of the act relates to the so-called significant utility cases. As to those inventions which the Commissioner of Patents believes to have significant utility in the conduct of aeronautical and space activities, no patent may be issued unless the applicant first files with the Commissioner a written statement, under oath, setting forth the facts and circumstances under which the invention was made and the relationship, if any, of the invention to the performance of any work under any contract with the administration. Each of these statements and the related application is transmitted to NASA and must be processed within 90 days thereafter.

Here again some difficulties are encountered in the administration of this provision of the statute because of the fact that the term "significant utility" is not readily definable. NASA is now in the process of consulting with Patent Office officials on this matter. Dangers are perceived from experience to date with the transmittal procedure. A uselessly great number of statements and related applications may be transmitted if the term "significant utility" is applied too broadly. The interests of the United States may not be protected if it is applied too narrowly. Moreover, the interests of patent applicants should not be overlooked. The aims of NASA in working with the Patent Office are to develop procedures under subsection (c) that are both workable and sound, to protect the interests of the Government, and to avoid adverse effects upon the legitimate interests of patent applicants.

There has been some misapprehension by the public that NASA, pursuant to subsection (d), might require the issuance to the Administrator of patents for any invention having significant utility in the conduct of aeronautical and space activities, regardless of whether the invention was made under a NASA contract. Subsections (c) and (d), in this connection, must be interpreted together. It has been concluded by NASA that these subsections were not intended to give the Government rights under inventions made by the public outside the scope of work done under a contract of NASA but were intended to assist the Administrator in detecting those inventions which should be considered by him for the purpose of determining whether they were made under the circumstances and conditions defined in subsection (a) so as to become the exclusive property of the United States. Ordinarily, the transmittal of patent applications from the Commissioner of Patents to the Administrator should be unnecessary for this purpose, since the contractor is required by the "Property Rights in Inventions" clause to report such inventions to NASA. However, the transmittal procedure of subsection (c) will be useful as a double check and will be particularly effective in those cases where the contractor may have inadvertently failed to report an invention or may contend that the invention was not made in the performance of a NASA contract, or where the employee may have failed to disclose the invention to the contractor, or where the "Property Rights in Inventions" clause may have been omitted inadvertently from the contract.

Subsections (c) and (d) are well conceived as policing procedures in support of the rights of the Government. It would be unreasonably extreme to regard

them as substantive provisions conveying to the Government rights in inventions of a specified class regardless of the circumstances under which such inventions are made. It appears reasonable that subsection (c) has as one of its purposes the aim of making available to NASA all the technology contained in all patent applications of the specified class. Most of the present technology of this country has passed through the Patent Office at some earlier time. Presumably, Congress intended that NASA should be informed, prior to the issuance of any patents, of this vast store of technology in the case of inventions having significant utility in the conduct of aeronautical and space activities. If, as a result of reviewing patent applications transmitted under subsection (c), an application is discovered disclosing technology which has significant utility in the conduct of aeronautical and space activities but which was not developed under a contract of NASA, NASA may then negotiate with the owner of the application for rights thereunder.

APPENDIX A

CONTRACT CLAUSES PRESCRIBED BY PART 1 OF NASA PATENT REGULATIONS

IX–A—PRESCRIBED BY PARAGRAPH 101.2

PROPERTY RIGHTS IN INVENTIONS

(a) As used in this clause—

(i) "person" means any individual, partnership, corporation, association, institution or other entity;

(ii) "made" or "making," when used in relation to any invention, means the conception or first actual reduction to practice of such invention;

(iii) "invention" includes any invention, discovery, improvement or innovation.

(b) This contract is subject to the provisions of section 305 of the National Aeronautics and Space Act of 1958 (hereinafter referred to as "the Act") relating to property rights in inventions. The Contractor shall furnish to the Contracting Officer a written report containing full and complete technical information concerning any invention made in the performance of any work under this contract promptly upon the making of such invention. The Contractor shall also furnish to the Contracting Officer, promptly after the execution of this contract, a written report containing full and complete technical information concerning any invention made in the performance of any work relating to the subject matter of this contract which was done upon an understanding in writing that a contract would be awarded.

(c) In addition to the report required by (b) above, the Contractor shall make a final report prior to final settlement of this contract listing all inventions reportable under (b) above, whether or not included in prior reports.

(d) It is hereby agreed by the parties hereto that any invention made in the performance of work under this contract shall be presumed to have been made by a person described in paragraphs (1) or (2) of subsection 305(a) of the Act, and under the conditions therein described, unless the Contractor, at the time of furnishing the report of an invention required by (b) above, does one of the following:

(i) submits to the Administrator a written statement setting forth details of the circumstances under which such invention was made so as to permit the Administrator to determine (A) whether the person who made the invention was employed or assigned to perform research, development or exploration work and the invention (1) is related to the work he was employed or assigned to perform, or (2) was within the scope of his employment duties; or (B) whether the invention is related to the contact, or to the work or duties which the person who made the invention was employed or assigned to perform, and was made during working hours or with a contribution by the Government of the use of Government facilities, equipment, materials, allocated funds, information proprietary to the Government, or services of Government employees during working hours; or

(ii) requests in writing an extension of time, not exceeding 3 months, to prepare and submit the written statement described in (i) above; or

(iii) notifies the Administrator of its intention to file a United States patent application for such invention within a period of 8 months from the date of furnishing the report of such invention required by (b) above; or

(iv) requests an advisory opinion concerning waiver of rights of the United States with respect to such invention.

(e) (i) If the Contractor submits the statement described in (d) (i) above, the Administrator will review the information furnished by the Contractor and any other available information relating to the circumstances surrounding the making of the invention in question, and will promptly notify the Contractor of his decision as to whether the invention was made under the circumstances set forth in paragraphs (1) and (2) of subsection 305(a) of the Act.

(ii) If the Contractor requests an extension of time for submission of such statement as provided in (d) (ii) above, but fails to submit the statement within the time prescribed therein, the presumption stated in (d) above shall take effect.

(iii) If the Contractor notifies the Administrator of its intention to file a patent application as provided in (d) (iii) above, but fails to file the patent application within the 8-month period prescribed therein, the presumption stated in (d) above shall take effect.

(iv) If the Contractor requests an advisory opinion as provided in (d) (iv) above, the Contractor will be notified of action thereon within 3 months of such request. If the Contractor considers that the advisory opinion is unfavorable to its interests and desires to take issue with the presumption stated in (a) above, it shall either submit the written statement described in (d) (i) above within 3 months from the date of mailing the advisory opinion, or promptly notify the Administrator of its intention to file a United States patent application for such invention within the remaining portion of the period prescribed in (d) (iii) above. If the Contractor fails either to submit the statement within 3 months from the date of mailing such advisory opinion, or to file the patent application before expiration of the period prescribed in (d) (iii) above, the presumption stated in (d) above shall take effect.

(v) If the Contractor files a patent application within the period prescribed in (d) (iii) above, it shall file with the Commissioner of Patents, at the time of filing the application in the Patent Office, a written statement of the applicant, executed under oath, conforming to the requirements of (d) (i) above, and shall furnish to the Contracting Office a copy of said application and of the written statement, identifying the application by serial number and filing date and the written statement by the contract number under which the invention was made. The Administrator will review the information furnished by the Contractor in such written statement and any other available information relating to the circumstances surrounding the making of the invention in question and will promptly notify the Contractor of his decision as to whether the invention was made under the circumstances set forth in paragraphs (1) and (2) of subsection 305(a) of the Act.

(f) With respect to any invention hereunder which becomes the exclusive property of the United States, the Contractor, upon written request, shall

(i) furnish to the Contracting Officer such additional technical details available to the Contractor and covering the invention as are necessary for the preparation of a patent application, and convey or secure the conveyance of the Contractor's entire right, title, and interest in such inventions to the Government by delivering to the Contracting Officer such duly executed instruments of assignment and application and such other papers as are deemed necessary to vest in the Government the Contractor's right, title, and interest aforesaid, and the right to apply for and prosecute patent applications covering such invention throughout the world; or

(ii) in the event of waiver under subsection 305(f) of the Act, take suitable and necessary steps (as set forth in (g) (ii) below or otherwise provided in the instrument of waiver) to protect the Government's interest in any such inventions of the Contractor or its employees and to grant to the Government the license right required by subsection 305(f) of the Act.

(g) (i) With respect to inventions as to which rights have not been vested in the Government pursuant to the provisions of Section 305 of the Act, and which were conceived or first actually reduced to practice (A) in the performance of the experimental, developmental, or research work called for or required under this contract, or (B) in the performance of any experimental, developmental, or research work relating to the subject matter of this contract which was done upon an understanding in writing that a contract would be awarded, the Contractor agrees to and does hereby grant to the Government an irrevocable, nonexclusive, nontransferable, and royalty-free license to practice and cause to

be practiced, by or for the United States Government, throughout the world, each such invention in the manufacture, use, and disposition according to law of any article or material, or in the use of any method. No license granted under this paragraph (g) shall convey any right to the Government to manufacture, have manufactured, or use any such invention for the purpose of providing services or supplies to the general public in competition with the Contractor or the Contractor's commercial licensees in the licensed fields. The obligation of the Contractor contained in (i), (ii)(C), and (ii)(E) of this paragraph (g) shall be limited to the extent of the Contractor's right to make the specified grants or conveyances without incurring any obligation to pay royalties or other compensation to others solely on account of said grant. Any license granted herein does not imply the grant to the Government of license rights under any other invention not subject to the licensing provisions hereof, notwithstanding that the practice of any invention licensed hereunder would necessarily require a license under a dominating patent or patents.

(ii) In connection with any invention covered by (g)(i) above, the Contractor shall do the following:

(A) specify whether or not a United States patent application claiming the invention has been or will be filed by or on behalf of the Contractor;

(B) if the Contractor specifies that a United States patent application claiming such invention will be filed, the Contractor shall file or cause to be filed such application in due form and time; however, if the Contractor, after having specified that such an application would be filed, decides not to file or cause to be filed said application, the Contractor shall so notify the Contracting Officer at the earliest practicable date and in any event not later than eight months after first publication, public use, or sale;

(C) if the Contractor specifies that a United States patent application claiming such invention has not been filed and will not be filed (or having specified that such an application will be filed thereafter notifies the Contracting Officer to the contrary), the Contractor shall:

(1) inform the Contracting Officer in writing at the earliest practicable date of any publication of such invention made by or known to the Contractor or, where applicable, of any contemplated publication by the Contractor, stating the date and identity of such publication or contemplated publication; and

(2) convey to the Government the Contractor's entire right, title, and interest in such invention by delivering to the Contracting Officer upon written request such duly executed instruments (prepared by the Government) of assignment and application and such other papers as are deemed necessary to vest in the Government the Contractor's right, title, and interest aforesaid, and the right to apply for and prosecute patent applications covering such invention throughout the world, subject, however, to the rights of the Contractor in foreign applications as provided in (iii) below, and subject further to the reservation of a nonexlusive and royalty-free license to the Contractor (and to its existing and future associated and affiliated companies, if any, within the corporate structure of which the Contractor is a part) which license shall be assignable to the successor of that part of the Contractor's business to which such invention pertains;

(D) the Contractor shall furnish promptly to the Contracting Officer on request an irrevocable power of attorney to inspect and make copies of each United States patent application filed by or on behalf of the Contractor covering any such invention;

(E) in the event the Contractor, or those other than the Government deriving rights from the Contractor, elects not to continue prosecution of any United States patent application specified in (B) above, filed by or on behalf of the Contractor, the Contractor shall so notify the Contracting Officer not less than sixty days before the expiration of the response period and, upon written request, deliver to the Contracting Officer such duly executed instruments (prepared by the Government) as are deemed necessary to vest in the Government the Contractor's entire right, title, and interest in such invention and the application, subject to the reservation as specified in (C) above; and

(F) the Contractor shall deliver to the Contracting Officer duly executed instruments fully confirmatory of any license rights herein agreed to be granted to the Government.

(iii) The Contractor, or those other than the Government deriving rights from the Contractor, shall, as between the parties hereto, have the exclusive right to file applications on inventions covered in (g)(i) above in each foreign country within:

(A) nine months from the date a corresponding United States application is filed;

(B) six months from the date permission is granted to file foreign applications where such filing had been prohibited for security reasons; or

(C) such longer period as may be approved by the Contracting Officer. The Contractor shall, upon written request of the Contracting Officer, convey to the Government the Contractor's entire right, title, and interest in each such invention in each foreign country in which an application has not been filed within the time above specified, subject to the reservation of a nonexclusive and royalty-free license to the Contractor together with the right of the Contractor to grant sublicenses, which license and right shall be assignable to the successor of that part of the Contractor's business to which the invention pertains.

(h)(i) In each subcontract hereunder which, pursuant to specifications or special requirements, has as one of its purposes the performance of technical, scientific, or engineering work of the kind described below, the Contractor shall include, at no increase in the cost or price of the subcontract or of this contract by reason of such inclusion, provisions which follow substantially (a) through (g) of this clause. The kinds of work referred to above are:

(A) the conduct of basic or applied research;

(B) the design or development, or the manufacture for the first time, of any machine, article of manufacture, or composition of matter to satisfy NASA's specifications or special requirements;

(C) the development of any process or technique for attaining a NASA objective not readily attainable through the practice of a previously process or technique; or

(D) the testing or experimenting with any machine, article of manufacture, composition of matter, process, or technique to determine whether the same is suitable or could be made suitable for a NASA objective.

In the event of refusal by a subcontractor to accept such provisions, the Contractor shall notify the Contracting Officer and shall not execute the subcontract in question until provisions have been negotiated with such subcontractor which, as determined by the Contracting Officer in writing, meet the requirements of the Act and are otherwise acceptable.

(ii) The Contractor is not required, when contracting with a subcontractor, to obtain on behalf of the Government any rights in the inventions covered in (g)(i) above other than as specifically provided in (g) above. However, the contractor is not precluded from contracting with a subcontractor, for the Contractor's own benefit, for rights in inventions covered in (g)(i) above, but any cost so incurred shall not be considered as an allowable charge or cost under this contract.

(i) The Contractor shall, at the earliest practicable date, notify the Contracting Officer in writing of any subcontract hereunder which contains the provisions required by (h) above and shall also notify the Contracting Officer when such subcontract is completed. It is understood that the purpose of the notice required by this paragraph is to permit the Government to enforce its rights under the Act. The Contractor shall not be obligated to enforce the agreements of any subcontractor hereunder relating to any invention, discovery, improvement, or innovation which may be made in the performance of any subcontract work.

(j) When the Contractor shows that it has been delayed in the performance of this contract by reason of the Contractor's inability to obtain, in accordance with the requirements of (h) above, the prescribed or other authorized patent clause from a qualified subcontractor for any items or service required under this contract for which the Contractor itself does not have available facilities or qualified personnel, the Contractor's delivery dates shall be extended for a period of time equal to the duration of such delay. Upon request of the Contractor, the Contracting Officer shall determine to what extent, if any, an additional extension of the delivery dates and increase in contract prices based upon additional costs incurred by such delay are proper under the circumstances; and the contract shall be modified accordingly.

(k) If the Contractor fails to comply with the reporting requirements of (b) and (c) above, there shall be withheld from payment, until the Contractor shall have corrected such failures, either ten per cent (10%) of the amount of this contract, as from time to time amended, or five thousand dollars ($5,000) whichever is less. After payment of eighty-five percent (85%) of the amount of this contract, as from time to time amended, payment shall be withheld until a reserve of either ten percent (10%) of such amount, or five thousand dollars ($5,000), whichever is less, shall have been set aside, such reserve or balance to be retained until the Contractor shall have furnished to the Contracting Officer a statement that the reporting requirements of (b) and (c) above have been complied with. No amount shall be withheld under this paragraph (k) when the amount specified by this paragraph (k) is being withheld under other provisions of this contract. The withholding of any amount or susbequent payment thereof to the Contractor shall not be construed as a waiver of any rights accruing to the Government under this contract. This paragraph (k) shall not be construed as requiring the Contractor to withhold any amounts from a subcontractor to enforce compliance with the patent provisions of a subcontract.

(l) The provisions of this paragraph (l) shall be applicable only if the technical, scientific, or engineering work to be performed hereunder relates to atomic energy.

(i) With respect to any invention as herein defined, made by employees of the Contractor and relating to the production or utilization of special nuclear material or atomic energy within the purview of the Atomic Energy Acts of 1946 (42 U.S.C. 1801–1819) and of 1954, as amended (42 U.S.C. 2011–2296), the Contractor agrees—

(A) the Administrator shall, in the exercise of his discretion and judgment, furnish to the United States Atomic Energy Commission (hereinafter in this paragraph (l) referred to as the "Commission") complete information regarding any such invention that the Administrator believes to relate to the production or utilization of special nuclear material or atomic energy;

(B) as to those inventions upon which said information is furnished by the Administrator to the Commission, and as to which rights have not been vested in the Government pursuant to the provisions of subsection 305(a) of the Act, the Commission shall have the sole and conclusive power to determine whether and where a patent application shall be filed, and to determine the disposition of title to and rights under any such application or any patent that may issue thereon;

(C) to obtain the execution and delivery through the Contracting Officer to the Commission of documents relating to each such invention and to do all things necessary or proper to carry out any determination of the Commission made under (B) above;

(D) unless otherwise authorized in writing by the Commission through the Contracting Officer, to obtain patent agreements from all such employees to effectuate the purpose of this program; and

(E) unless otherwise authorized in writing by the Commission to the Contracting Officer, to insert this paragraph (l) in all subcontracts.

(ii) No claim for a pecuniary award or compensation under the provisions of the Atomic Energy Acts of 1946 and of 1954 shall be asserted by the Contractor or its employees with respect to any invention covered by this paragraph (l).

[Reprint of Pages 1644–1649 of the Federal Register, March 5, 1959]

Title 32—NATIONAL DEFENSE

Chapter XII—National Aeronautics and Space Administration

PART 1201—PATENTS

Notice is hereby given that the Administrator of the National Aeronautics and Space Administration, acting pursuant to subsection 305(f) of the National Aeronautics and Space Act of 1958, has prescribed interim regulations setting forth policies and procedures concerning waiver of all or any part of the rights of the United States with respect to inventions made in the performance of work

required by contracts of the National Aeronautics and Space Administration. The interim regulations have been denominated Part 3 of the Patent Regulations (32 CFR Part 1201) of the National Aeronautics and Space Administration. Other parts of the Patent Regulations are in process of preparation.

All persons desiring to submit comments or suggestions concerning the interim regulations may do so by filing them with the General Counsel of the National Aeronautics and Space Administration, 1520 H Street NW., Washington 25, D.C., not later than 60 days following publication of this notice in the FEDERAL REGISTER. On May 18, 1959, at 9:30 a.m. a public hearing will be held in the auditorium of the National Aeronautics and Space Administration, at the foregoing address, at which time and place oral presentation of comments or suggestions concerning the interim regulations may be made. In order that an agenda for such public hearing may be prepared, each person desiring to make an oral presentation is requested to submit a brief outline thereof to the General Counsel of the National Aeronautics and Space Administration not later than May 1, 1959.

The interim regulations are as follows:

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AUTHORITY: §§ 1201.300 to 1201.404 issued under secs. 203, 305, Pub. Law 85–568.

Subpart A—[Reserved]

Subpart B—[Reserved]

Subpart C—Waiver of Patent Rights

§ 1201.300 Scope of subpart.

(a) The Administrator is authorized by subsection 305(f) of the National Aeronautics and Space Act of 1958, under such regulations as he shall prescribe, to waive all or any part of the rights of the United States with respect to any invention or class of inventions made or which may be made by any person or class of persons in the performance of any work required by any contract of the Administration if the Administrator determines that the interests of the United States will be served thereby.

(b) This subpart sets forth the regulations which the Administrator has prescribed for the granting of such waivers, and contains the policies, requirements, and procedures governing the waiver of all or any part of the rights of the United States with respect to such inventions.

§ 1201.301 Applicability.

This subpart is applicable only to those inventions (a) made in the performance of work under a contract of the Administration containing a "Property Rights in Inventions," clause, and (b) as to which the Administrator has made a determination, either pursuant to the presumptions contained in the "Property

Rights in Inventions" clause or subsequent to a review of statements submitted by the contractor, that the invention was made by a person described in paragraphs (1) or (2) of subsection 305 (a) of the Act and under the conditions therein described; and (c) as to which title in the United States has not been formalized by instruments of assignment.

§ 1201.302 Definitions.

As used in this subpart, the following terms have the meanings set forth below:

(a) "Administration" and "Administrator" mean the National Aeronautics and Space Administration and the Administrator thereof, respectively.

(b) "Section 305" means section 305 of the National Aeronautics and Space Act of 1958 (Pub. Law 85–568).

(c) "Inventions and Contributions Board" means the Board of that name established by the Administrator pursuant to section 305.

(d) "Board" means the Inventions and Contributions Board.

(e) The term "person", "contract", and "made" have the same meanings as assigned in section 305.

(f) The term "contractor" includes a subcontractor, or the inventor when the inventor is not under an obligation to assign the invention to the contractor.

(g) "Develop to the point of practical application," referring to an invention to which this subpart is applicable, means manufactured, if a composition or product, practiced if a process, or operated if a machine, and under such conditions as to have established its availability to the public.

(h) "Waiver" means the act of disclaiming title or of agreeing to grant to the contractor a license, or an assignment of foreign rights, under an invention to which this subpart is applicable before execution of instruments of assignment of the invention to the United States.

(i) "Instrument of waiver" means the document signed by the Administrator or his designee evidencing the waiver.

§ 1201.303 Policy.

It is generally accepted that the interests of the United States are best served through the maintenance of a freely competitive economy supported by the United States Patent System as a stimulus for creative work. An important function of the patent, or of exclusive rights to or under the patent, is the protection which the patent or such rights gives to the investment of the person or firm who undertakes to develop the invention to the point of practical application. The Administrator considers that the interests of the United States will be served by making available to the public, under general licensing regulations promulgated under subsection 305(g) of the Act, inventions owned by the United States, unless the interests of the United States would be better served by granting a waiver to the contractor. The Administrator further considers that waiver to the contractor would be in the interests of the United States where (a) the stimulus of ownership of patent rights will encourage the contractor to develop the invention to the point of practical application earlier than would otherwise be the case, or (b) there are substantial equities justifying the retention of rights by the contractor.

§ 1201.304 Criteria for granting waivers.

§ 1201.304–1 Inventions not generally eligible for waiver.

Pending the further development of space technology, the interests of the United States would not generally be served by waiver of the rights of the United States with respect to any invention which is (a) primarily adapted for and especially useful in the development and operation of vehicles, manned or unmanned, capable of flight without support from the atmosphere, or (b) of basic importance to the continued progress of aeronautical and space activities: *Provided*, That the foregoing shall not preclude the Administrator from granting a waiver as to such inventions under § 1201.304–3.

§ 1201.304–2 Prima facie case for waiver.

Except for inventions described in § 1201.304–1, the Administrator considers that a prima facie case that the interests of the United States would be served by waiver shall have been established when

(a) It is shown that the invention was conceived prior to and independently of, but was first actually reduced to practice in the performance of work under a contract of the Administration, and the invention is covered by a United

States patent issued or application filed by or on behalf of the contractor prior to the award of the contract; or

(b) It appears that the invention has only incidental utility in the conduct of activities with which the Administration is particularly concerned and has substantial promise of commercial utility; or

(c) It is shown that the invention is directed specifically to a line of business of the contractor with respect to which the contractor's expenditure of funds in the field of technology to which the invention pertains has been large in comparison to the amount of funds paid or to be paid to the contractor under the contract in which the invention was made for research or development work in the same field of technology; or

(d) The waiver requested is for a nonexclusive, nontransferable, royalty-free license under an invention which does not qualify for waiver of greater rights under circumstances in paragraphs (a) through (c) of this section; or

(e) The waiver requested is for rights to an invention in a country or countries other than the United States in which the Administration does not desire to file an application for patent for such invention.

§ 1201.304–3 Other inventions and rights.

The Administrator may grant whatever waiver of rights appears appropriate under the circumstances, under an invention which does not qualify for waiver under § 1201.304–2 whenever the contractor shows to the satisfaction of the Administrator that the grant of waiver under such an invention would be in the interests of the United States in accordance with the general policy enunciated in § 1201.303.

§ 1201.305 Conditions and extent of waiver.

§ 1201.305–1 General.

The rights which the Administrator may waive under an invention may vary as to extent, i.e., title, exclusive license, or nonexclusive license, and as to the term of years. All waivers shall be subject to the reservation of an irrevocable, nonexclusive, nontransferable, royalty-free license for the practice of such invention throughout the world by or on behalf of the United States or any foreign government pursuant to any treaty or agreement with the United States. No waiver shall be valid unless accepted in writing by the contractor. Instruments of waiver shall provide that the waiver is voidable at the option of the Administrator (a) if the contractor shall have failed to comply with a material condition of the waiver, or (b) if it is subsequently discovered that the grant of the waiver was based upon misrepresentation of a material fact: *Provided, however*, That the inclusion of conditions in a waiver or instrument of waiver, requiring certain acts or reports from the contractor, shall not be deemed to be a contract requiring the performance of work within the meaning of subsection 305(b) of the Act: *And provided further*, That inventions made by the contractor in connection with the development of an invention to the point of practical application as a part of compliance, or in attempting to comply, with a condition of a waiver or instrument of waiver, shall not be deemed from such fact alone to be inventions made in the performance of the type of work set forth in section 305.

§ 1201.305–2 Conditions applicable to specific rights.

Generally, when the Administrator determines that waiver is in the interest of the United States, he will waive rights to the extent and on the further conditions set forth in §§ 1021.305–3 through 1201.305–7.

§ 1201.305–3 Title.

(a) Title to the invention for the full term of the life of the patent will be waived when the waiver is under paragraph (a) of § 1201.304–2 or when such waiver is approved under § 1201.304–3.

(b) When the Administrator has determined that it is in the interests of the United States to waive rights under inventions falling within paragraph (b) or (c) of § 1201.304–2, the waiver granted will be the title to the invention, but such title shall be voidable at the option of the Administrator unless the contractor shall, on or before the end of the fifth year from the date of the contractor's acceptance of waiver, demonstrate to the Administrator that

(1) The invention has been developed to the point of practical application, or

(2) The invention has been made available for licensing either royalty-free or at a reasonable royalty rate, or

(3) There are circumstances justifying failure to realize the conditions of subparagraphs (1) and (2) of this paragraph and concurrently justifying a continuance of title in the contractor.

§ 1201.305–4 Exclusive license.

The waiver may take the form of a grant of an exclusive license on appropriate terms and conditions if the contractor should request such a license.

§ 1201.305–5 Nonexclusive license.

A nonexclusive license waived under paragraph (d) of § 1201.304–2 shall be voidable, at the option of the Administrator, after the end of the fifth year from the date of the contractor's acceptance of waiver, if

(a) The contractor, upon request by the Administrator, shall be unable to demonstrate that (1) the invention has been developed to the point of practical application, or (2) there are circumstances excusing the contractor from so developing the invention or justifying a continuance of the nonexclusive license to the contractor; and

(b) The Administrator has not made the invention generally available for licensing, nor granted a license or other right which is not revocable or terminable at such time.

§ 1201.305–6 Foreign rights.

Waivers made under paragraph (e) of § 1201.304–2 will be by disclaimer and assignment of title for the life of the patent in the foreign country for which the waiver is granted.

§ 1201.305–7 Special conditions.

In addition to the applicable conditions set forth in the preceding paragraphs, waivers shall be subject to (a) such special conditions as may be set forth in the instrument of waiver and (b) the provisions of paragraph (f) (iii) of the "Property Rights in Inventions" clause used in contacts of the Administration.

§ 1201.306 Procedures.

§ 1201.306–1 Petition.

Waivers will be granted only upon a petition addressed to the Administrator. Such petition shall

(a) Identify by number and date the contract under which the invention was made or to which the invention relates,

(b) Identify the invention by name of inventor, brief description, and the location of records wherein the invention is disclosed,

(c) State facts showing that the invention qualifies under the criteria of § 1201.304 for consideration for waiver,

(d) Specify the extent of waiver requested, i.e., title to the invention, exclusive license, nonexclusive license, or title to foreign rights; and in the case of foreign rights, specify the country or countries in which the contractor desires to file application for patents,

(e) State whether or not the contractor has filed or caused to be filed a patent application for such invention,

(f) If a patent application has not been filed, present any information which the contractor wishes to submit concerning publication, public use, or public sale of the invention, which would indicate the need for prompt action on the petition,

(g) Include any additional statements, in formation, or reasons in support of its request which petitioner desires to submit,

(h) Be signed by the petitioner.

Any statements required to be furnished under paragraphs (a) through (g) of this section may be attached to the petition if suitably identified and cross-referenced in the petition.

§ 1201.306–2 Proceeding of petitions.

(a) Petitions will be submitted to the Office of the General Counsel, National Aeronautics and Space Administration.

(b) The Assistant General Counsel for Patent Matters will review such petitions for compliance with § 1201.306–1 and prepare a Findings of Facts and Recommendation to the Inventions and Contributions Board with respect to each such petition which will state

(1) Whether, in his opinion, the petition sets forth facts which qualify the invention for waiver under one or more of the criteria in § 1201.304,

(2) A recommendation that waiver in the extent requested either be or not be granted, or in the alternative, that a waiver in an extent different from that requested, be granted,

(3) Any special conditions which should be included in the instrument of waiver.

(c) The Inventions and Contributions Board will consider the petition and Findings of Fact and Recommendation of the Assistant General Counsel for Patent Matters and notify the petitioner—

(1) Whether it proposes to recommend to the Administrator the granting of the waiver in the extent requested, in an extent different from that requested, or the denial of the request;

(2) Of any conditions upon which it proposes to recommend the granting of the waiver;

(3) Of the reasons for any action which is adverse to or different from the waiver requested by the petitioner; and

(4) That the petitioner may, within 30 days from receipt of the notification, request an oral hearing before the Board, in the event the petitioner is not satisfied with the action the Board proposes to recommend.

(d) If the petitioner requests a hearing, the Board will set a place and date for such hearing, notify the petitioner and the Assistant General Counsel, and hold such hearing in accordance with rules approved by the Administrator.

(e) If the Board has proposed to recommend the granting of a waiver and the petitioner has not requested a hearing within 30 days as above provided, the Board shall transmit to the Administrator an instrument of waiver in the extent proposed to be granted for approval by the Administrator, together with its recommendation that the waiver be approved.

(f) After a hearing as provided in paragraph (d) of this section, the Board shall transmit to the Administrator the petition, the record of proceedings, its findings of fact with respect to the request for waiver, and its recommendation for action to be taken with respect thereto.

(g) The Administrator may either (1) approve the waiver and direct that the instrument of waiver be delivered to the petitioner; (2) inform the petitioner of his decision if adverse; or (3) refer the matter to the Board for further proceeding in accordance with his instructions.

§ 1201.306–3. Procedure pending grant of waiver when statutory bar is running against the invention.

Whenever it appears that a statutory bar is running against the filing of an application for patent for the invention during the course of this procedure, and that delay in acting on the petition for waiver might result in loss of the patent rights in the invention, the Assistant General Counsel for Patent Matters shall arrange with the contractor for the preparation and filing of the patent application by the contractor pending the action on the waiver, subject to reimbursement of the reasonable costs of the contractor if the waiver is not approved in a form acceptable to the contractor.

§ 1201.306–4 Form of waiver.

(a) *Assignment.* When waiver is approved for disclaimer of title, there will be furnished to the contractor an instrument of waiver which permits the contractor to retain title but requires the furnishing to the United States, as represented by the Administrator, at the time of filing the application for patent, a confirmatory license (prepared by the Government) of the rights reserved to the United States. When the waiver is approved under § 1201.305–3(a) the instrument of waiver will be in the form of § 1201.401 and when the waiver is approved under § 1201.305–3(b), the instrument of waiver will be in the form of § 1201.402 which contains the additional conditions required by § 1201.305–3(b).

(b) *Exclusive license.* When the waiver is an exclusive license, there will be furnished an instrument of waiver which, in general, agrees to grant to the contractor, at the time the application is filed, an exclusive license, except for the rights reserved to the United States, upon the conditions that the contractor

(1) Prepare the application for patent;

(2) Execute or cause to be executed instruments of mesne assignment of the invention (prepared by the Government) in favor of the United States, as represented by the Administrator;

(3) Forward to the Administrator such application for patent, properly executed, for filing in Patent Office, and such instruments of mesne assignment for acceptance by the Administrator;

(4) Arrange for prosecution of the application under an associate power of attorney and under the procedures and conditions set forth in the instrument of waiver; and

(5) Such other conditions as are appropriate to the grant.

(c) *Nonexclusive license.* When the waiver is approved for nonexclusive license, there will be furnished to the contractor an instrument of waiver in the form of § 1201.403 granting an irrevocable, nonexclusive, and royalty-free license to the contractor (and its existing and future associated and affiliated companies, if any, within the corporate structure of which the contractor is a part), together with the right to sublicense others to the extent that the contractor is obligated prior to the contract to grant such sublicenses, which license and right shall be assignable to the successors of that part of the contractor's business to which such invention pertains. The instruments of mesne assignment, prepared by the Government for execution by contractor and delivery to the Administrator in accordance with paragraph (e) of the "Property Rights in Inventions" clause, will be subject to and acknowledge therein the reservation to the contractor of the license grant set out in the instrument of waiver.

(d) *Foreign rights.* When the waiver is approved for territorial rights to an invention in any country or countries other than the United States, there will be furnished to the contractor an instrument of waiver in the form of § 1201.404 which will permit the contractor to prepare and file an application for patent in such other country or countries, subject to the contractor obtaining such licenses, or clearances as to secrecy, as may be necessary for exportation of such application and the filing thereof in such other country or countries. The instrument of waiver will also set forth an agreement to assign to the contractor the entire right, title, and interest in such invention in each foreign country as to which the rights are waived and in which an application is to be filed by the contractor, subject to the reservation of an irrevocable, nonexclusive, nontransferable, royalty-free license for the practice of such invention throughout the world by or on behalf of the United States or any foreign Government pursuant to any treaty or agreement with the United States, upon the conditions that the contractor

(i) "Instrument of waiver" means the United States Government a United States patent application covering the invention;

(2) Execute or cause to be executed instruments of mesne assignment of the invention (prepared by the Government) in favor of the United States, as represented by the Administrator; and

(3) Forward to the Administrator such application for patent, properly executed, for filing in the Patent Office, and such instruments of mesne assignment for acceptance by the Administrator.

§ 1201.401 Instrument of waiver; title.

NASA Case No. _____

Appl'n Serial No. _____
Filed _____

Inventor (Name) _____
Title of invention _____
Contractor _____
(Name of person receiving waiver—contractor, subcontractor, or inventor)
Address of person receiving waiver _____
Contract No. _____

Contractor's Disclosure No. _____

Whereas the invention above identified was made in the performance of work under the above identified contract with the National Aeronautics and Space Administration (hereinafter referred to as the Administration); and

Whereas the Administrator of the National Aeronautics and Space Administration has determined that the invention above identified was made under the provisions of subsection 305(a) of the National Aeronautics and Space Act of 1958 so as to become the exclusive property of the United States; and

Whereas the Administrator has determined, in accordance with the regulations he has prescribed under subsection 305(f) of said Act, that the interests of the United States will be served by waiver to _____
(Name of person receiving waiver)
(hereinafter sometimes referred to as Contractor) of rights vested, or which otherwise would have vested, in the United States, to the above identified invention (hereinafter referred to as said invention);

Now therefore, subject to the conditions and procedures hereinafter specified, and acceptance thereof by the Contractor:

1. The Administrator disclaims and waives in favor of _____
(Name of person receiving waiver)
the rights of the United States (i) to acquire exclusive ownership of said invention, (ii) the right to apply for United States and foreign patents for said invention, and (iii) the right to have the same issue to the Administrator on behalf of the United States; subject however to the reservation by the Administrator of an irrevocable, nonexclusive, nontrans-

ferable, royalty-free license for the practice of said invention throughout the world by or on behalf of the United States or any foreign Government pursuant to any treaty or agreement with the United States.

2. This disclaimer and waiver is conditioned upon the Contractor doing the following:

(A) Furnishing promptly to the Administrator on request an irrevocable power to inspect and make copies of each United States patent application filed by or on behalf of the Contractor covering said invention.

(B) In the event the Contractor (or those, other than the United States Government, deriving rights from the Contractor) elects not to continue prosecution of any such United States patent application filed by or on behalf of the Contractor:

Notify the Administrator of such election not less than sixty days before the expiration of the response period and, upon written request, deliver to the administrator such duly executed instruments (prepared by the Government) as are deemed necessary to vest in the Administrator the entire right, title and interest in such invention and the application, subject, however, to the rights of the Contractor in foreign applications as provided in (D) below, and subject further to the reservation of a nonexclusive and royalty-free license to the Contractor (and to its existing and future associated and affiliated companies, if any, within the corporate structure of which the Contractor is a part), together with the right to sublicense others to the extent that the Contractor is obligated, prior to the contract under which said invention was made, to grant such sublicenses; which license and right shall be assignable to the successor of that part of the Contractor's business to which the invention pertains.

(C) In the event any United States patent application filed on said invention becomes involved in interference proceedings:

Make no "concession of priority" nor "abandonment of contest" without either (i) first having referred the matter to the Administrator and given due consideration to his recommendations, if any; or (ii) obtaining an irrevocable, nonexclusive non transferable, royalty-free license for the practice of such invention throughout the world by or on behalf of the United States or any foreign Government pursuant to any treaty or agreement with the United States, under the invention which is the subject of the "concession of priority" or under the invention in favor of which the "abandonment of contest" is made.

(D) With respect to any foreign country in which the Contractor (or those, other than the United States Government, deriving rights from the Contractor) has not filed an application on said invention within (i) nine months from the date a corresponding United States application is filed; (ii) six months from the date permission is granted to file foreign applications where such filing had been prohibited for security reasons; or (iii) such longer periods as may be approved by the Administrator.

Convey to the United States Government upon written request the Contractor's entire right, title, and interest in said invention in such foreign country or countries in which an application for patent has not been filed within the times above specified, subject to the reservation of a nonexclusive and royalty-free license to the Contractor (and to its existing and future associated and affiliated companies, if any, within the corporate structure of which the Contractor is a part) together with the right to sublicense others to the extent that the Contractor is obligated, prior to the contract under which said invention was made, to grant such sublicenses; which license and right shall be assignable to the successor of that part of the Contractor's business to which the invention pertains.

(E) Delivering to the Administrator duly executed instruments (prepared by the Government) fully confirmatory of the license rights herein reserved by the Administrator.

(F) Requiring each instrument granting any license or sublicense to practice said invention covered by an application for patent or patents issuing thereon to contain a notation of the royalty-free license reserved by the Administrator.

(G) Furnishing upon request of the Administrator information concerning the grant of any licenses to practice said invention under such applications for patent or patents issuing thereon, together with the relevant terms and conditions thereof.

3. This Instrument of Waiver, waiver, and disclaimer, is voidable, at the option of the Administrator:

(A) If the Contractor shall have failed to comply with a material condition of the waiver as set forth herein; or

(B) If it is subsequently discovered that the waiver was based upon misrepresentation of a material fact.

Signed at Washington, D.C., this _____ day of _____, 19__.

By direction of the Administrator, National Aeronautics and Space Administration.

_____

The Contractor has caused this instrument to be signed and attested by its duly authorized officers this _____ day of _____, 19__, accepting said instrument with the intent to be legally bound thereby.

_____
(Contractor)

By _____ _____
(Name) (Title)

_____
(Address)

_____
Attest.

§ 1201.402 Instrument of waiver; title; qualified.

NASA Case No. _____

Inventor (Name)_____

Title of invention_____

Contractor_____
(Name of person receiving waiver—contractor, subcontractor, or inventor)

Address of person receiving waiver_____

Contract No. _____ Contractor's Disclosure No. _____

Whereas the invention above identified was made in the performance of work under the above identified contract with the National Aeronautics and Space Administration (hereinafter referred to as the Administration); and

Whereas the Administrator of the National Aeronautics and Space Administration has determined that the invention above identified was made under the provisions of sub-

section 305(a) of the National Aeronautics and Space Act of 1958, so as to become the exclusive property of the United States; and

Whereas the Administrator has determined, in accordance with the regulations he has prescribed under subsection 305(f) of said Act, that the interests of the United States will be served by waiver to ----------

(Name of person receiving waiver)

(hereinafter sometimes referred to as Contractor) of rights vested, or which otherwise would have vested, in the United States, to the above identified invention (hereinafter referred to as said invention);

Now therefore, subject to the conditions and procedures hereinafter specified, and acceptance thereof by the Contractor:

1. The Administrator disclaims and waives in favor of ----------

(Name of person receiving waiver)

the rights of the United States (i) to acquire exclusive ownership of said invention, (ii) the right to apply for United States and foreign patents for said invention, and (iii) the right to have the same issue to the Administrator on behalf of the United States; subject however to the reservation by the Administrator of an irrevocable, nonexclusive, nontransferable, royalty-free license for the practice of said invention throughout the world by or on behalf of the United States or any foreign Government pursuant to any treaty or agreement with the United States.

2. This disclaimer and waiver is conditioned upon the Contractor doing the following:

(A) Filing or causing to be filed an application for United States patent in due form and time and without direct cost to the United States Government, or notifying the Administrator at the earliest practicable date and in any event not later than eight months after first publication, use or sale, of any decision not to file, stating the reasons for such decision.

(B) In the event of a decision of the Contractor not to file:

1. Inform the Administrator in writing at the earliest practical date of any publication of such invention made by or known to the Contractor, or where applicable, of any contemplated publication by the Contractor, stating the date and identity of such publication or contemplated publication; and

2. Convey to the United States Government as represented by the Administrator, the entire right, title, and interest in such invention by delivering to the Administrator upon written request such duly executed instruments (prepared by the Government) of assignment and application and such other papers as are deemed necessary to vest in the Administrator the right, title, and interest aforesaid, and the right to apply for and prosecute patent applications covering the invention throughout the world, subject, however, to the rights of the Contractor in foreign applications as provided in (F) below, and subject further to the reservation of a nonexclusive and royalty-free license to the Contractor (and to its existing and future associated and affiliated companies, if any, within the corporate structure of which the Contractor is a part), together with the right to sublicense others to the extent that the Contractor is obligated, prior to the contract under which said invention was made, to grant such sublicenses; which license and right shall be assignable to the successor of that part of the Contractor's business to which the invention pertains.

(C) Furnishing promptly to the Administrator on request an irrevocable power to inspect and make copies of each United States patent application filed by or on behalf of the Contractor covering said invention.

(D) In the event the Contractor (or those, other than the United States Government, deriving rights from the Contractor) elects not to continue prosecution of any such United States patent application filed by or on behalf of the Contractor:

Notify the Administrator of such election not less than sixty days before the expiration of the response period and, upon written request, deliver to the Administrator such duly executed instruments (prepared by the Government) as are deemed necessary to vest in the Administrator the entire right, title and interest in such invention and the application, subject to the reservations as specified in (B)2, above.

(E) In the event any United States patent application filed on said invention becomes involved in interference proceedings:

Make no "concession of priority" nor "abandonment of contest" without either (i) first having referred the matter to the Administrator and given due consideration to his recommendations, if any; or (ii) obtaining an irrevocable, nonexclusive, nontransferable, royalty-free license for the practice of such invention throughout the world by or on behalf of the United States or any foreign Government pursuant to any treaty or agreement with the United States, under the invention which is the subject of the "concession of priority" or under the invention in favor of which the "abandonment of contest" is made.

(F) With respect to any foreign country in which the Contractor (or those, other than the United States Government, deriving rights from the Contractor) has not filed an application on said invention within (i) nine months from the date a corresponding United States application is filed; (ii) six months from the date permission is granted to file foreign applications where such filing had been prohibited for security reasons; or (iii) such longer periods as may be approved by the Administrator.

Convey to the United States Government upon written request the Contractor's entire right, title and interest in said invention in such foreign country or countries in which an application for patent has not been filed within the times above specified, subject to the reservation of a nonexclusive and royalty-free license to the Contractor (and to its existing and future associated and affiliated companies, if any, within the corporate structure of which the Contractor is a part) together with the right to sublicense others to the extent that the Contractor is obligated, prior to the contract under which said invention was made, to grant such sublicenses; which license and right shall be assignable to the successor of that part of the Contractor's business to which the invention pertains.

(G) Delivering to the Administrator duly executed instruments (prepared by the Government) fully confirmatory of the license rights herein reserved by the Administrator.

(H) Requiring each instrument granting any license or sublicense to practice said invention covered by an application for patent or patents issuing thereon to contain a notation of the royalty-free license reserved by the Administrator.

(I) Furnishing upon request of the Administrator information concerning the grant of any licenses to practice said invention under such applications for patent or patents issuing thereon, together with the relevant terms and conditions thereof.

3. This Instrument of Waiver, waiver, and disclaimer, is voidable, at the option of the Administrator:

(A) Unless the Contractor shall, on or before the end of the fifth year from the date of the Contractor's acceptance of waiver, demonstrate to the Administrator that

(i) The invention has been developed to the point of practical application, or

(ii) The invention has been made available for licensing either royalty-free or at a reasonable royalty rate, or

(iii) There are circumstances justifying failure to realize the conditions of (i) and (ii) above and concurrently justifying a continuance of title in the contractor.

The phrase "developed to the point of practical application" as used herein means "manufactured, if a composition or product, practiced if a process, or operated if a machine, and under such conditions as to have established its availability to the public."

(B) If the Contractor shall have failed to comply with a material condition of the waiver as set forth herein; or

(C) If it is subsequently discovered that the waiver was based upon misrepresentation of a material fact.

4. This Instrument of Waiver is deemed not to be a contract requiring the performance of work within the meaning of subsection 305(b) of the National Aeronautics and Space Act of 1958 (Pub. Law 85–568) nor shall inventions made by the Contractor in connection with the development of an invention to the point of practical operation as a part of compliance, or in attempting to comply, with 3.(A) above be deemed from such fact alone to have been made in the performance of the type of work set forth in Section 305 of said Act.

Signed at Washington, D.C., this _____ day of _____, 19____.

By direction of the Administrator, National Aeronautics and Space Administration.

Contractor's Acceptance and Agreement

The Contractor agrees to return this Instrument of Waiver to the Administrator of the National Aeronautics and Space Administration at the end of the fifth year from the date of the Contractor's acceptance of this instrument for endorsement thereon by the Administrator of one of the following:

(A) That the conditions upon which this Instrument of Waiver is based have been satisfied and that this waiver and disclaimer are no longer voidable at the option of the Administrator;

(B) That the conditions upon which this Instrument of Waiver is based have not been satisfied and that this waiver and disclaimer are void; or

(C) That there are circumstances justifying failure to satisfy the conditions upon which this Instrument of Waiver is based and concurrently justifying a continuance of title in the Contractor for the additional number of years stated in the endorsement.

The Contractor further agrees that the endorsement made by the Administator on this Instument in accordance with the circumstances set forth above shall be binding upon the Contractor, and in the event the Administrator, by his endorsement, voids this waiver and disclaimer, the Contractor agrees that such endorsement shall operate to restore to the United States Government the entire right, title and inteest in and to he said invention and any application for patent which may have been filed thereon, or any patent which may have been issued on any such application subiect to the reservation to the Contractor of the license and right reserved in paragraph 2(B)2 of this instrument.

The Contractor still further agrees that any of the above said endorsements shall be conclusive evidence as to the condition of title in said invention and the presentation thereof to the Commissioner of Patents shall authorize the Commissioner to record such condition of title as shown by said endorsement.

The Contractor has caused this instrument to be signed and attested by its duly authorized officers this _____ day of _____, 19____, with the intent to be legally bound thereby.

_____
(Contractor)

By _____ _____
(Name) (Title)

_____
(Address)

_____
Attest.

§ 1201.403 Instrument of waiver; nonexclusive license.

NASA Case No. _____

Inventor (Name) _____

Title of invention _____

Contractor _____
(Name of person receiving waiver—contractor, subcontractor, or inventor)

Address of person receiving waiver _____

Contract No. _____

Contractor's Disclosure No. _____

Whereas the invention above identified was made in the performance of work under the above identified contract with the National Aeronautics and Space Administration (hereinafter referred to as the Administration); and

Whereas the Administrator of the National Aeronautics and Space Administration has determined that the invention above identified was made under the provisions of subsection 305(a) of the National Aeronautics and Space Act of 1958 so as to become the exclusive property of the United States; and

Whereas the Administrator has determined, in accordance with the regulations he has prescribed under subsection 305(f) of said Act, that the interests of the United States will be served by waiver to _____ (hereinafter sometimes
(Name of person receiving waiver)

referred to as Contractor) of certain rights in the above identified invention (hereinafter referred to as said invention);

Now therefore, subject to the conditions and procedures hereinafter specified, and acceptance thereof by the Contractor:

1. The Administrator agrees to and does hereby grant to _____
(Name of person receiving waiver)
(and to its existing and future associated and affiliated companies, if any, within the corporate structure of which the Contractor is a part), a nonexclusive, royalty-free license, together with the right to sublicense others to the extent that the Contractor is obligated prior to the contract under which the said invention was made to grant such sublicenses, which license and right shall be assignable to the successor of that part of the Contractor's business to which the invention pertains.

2. This waiver and license grant is conditioned upon the Contractor doing the following:

Executing or causing to be executed mesne assignments (prepared by the Government) of said invention and delivering the same to the Administrator, in accordance with paragraph (e) of the "Property Rights in Inventions" clause of the contract under which said invention was made.

3. This Instrument of Waiver and license grant is voidable, at the option of the Administrator:

(A) After the end of the fifth year from the date of the Contractor's acceptance of this Instrument of Waiver, if

(i) The Contractor, upon request by the Administrator, shall be unable to demonstrate that (1) the invention has been developed to the point of practical application, or (2) there are circumstances excusing the Contractor from so developing the invention or justifying a continuance of the nonexclusive license to the Contractor; and

(ii) The Administrator has not made the invention generally available for licensing, nor granted a license or other right which is not revocable or terminable at such time.

The phrase "developed to the point of practical application" as used herein means "manufactured, if a composition or product, practiced if a process, or operated if a machine, and under such conditions as to have established its availability to the public.

(B) If the Contractor shall have failed to comply with a material condition of the Instrument of Waiver as set forth herein; or

(C) If it is subsequently discovered that the waiver was based upon misrepresentation of a material fact.

4. This Instrument of Waiver is not deemed to be a contract requiring the performance of work within the meaning of subsection 305(b) of the National Aeronautics and Space Act of 1958 (Pub. Law 85–568) nor shall inventions made by the Contractor in connection with the development of an invention to the point of practical operation, as a part of compliance, or in attempting to comply, with 3(A) above be deemed from such fact alone to have been made in the performance of the type of work set forth in Section 305 of said Act.

5. The Administrator agrees that the mesne assignments (prepared by the Government), referred to in paragraph 2 above, will be subject to, and will acknowledge therein in the form of reservation to the Contractor, the license grant set forth in paragraph 1 above.

Signed at Washington, D.C., this _____ day of _____, 19__.

By direction of the Administrator, National Aeronautics and Space Administration.

_____

The Contractor has caused this instrument to be signed and attested by its duly authorized officers this _____ day of _____, 19__, accepting said instrument with the intent to be legally bound thereby.

_____
(Contractor)

By _____ _____
(Name) (Title)

_____
(Address)

_____
Attest.

§ 1201.404 Instrument of Waiver; foreign rights.

NASA Case No. _____
Inventor (Name) _____
Title of invention _____
Contractor _____
(Name of person receiving waiver—contractor, subcontractor, or inventor)
Address of person receiving waiver _____
Contract No. _____
Contractor's Disclosure No. _____

Whereas the invention above identified was made in the performance of work under the above identified contract with the National Aeronautics and Space Administration (hereinafter referred to as the Administration); and

Whereas the Administrator of the National Aeronautics and Space Administration has determined that the invention above identified was made under the provisions of subsection 305(a) of the National Aeronautics and Space Act of 1958 so as to become the exclusive property of the United States; and

Whereas the Administrator has determined, in accordance with the regulations he has prescribed under subsection 305(f) of said Act, that the interests of the United States will be served by waiver to _____
(Name of person receiving waiver)
(hereinafter sometimes referred to as Contractor) of certain rights vested, or which otherwise would have vested, in the United States, to the above identified invention (hereinafter referred to as said invention);

Now therefore, subject to the conditions and procedures hereinafter specified, and acceptance thereof by the Contractor:

1. The Administrator disclaims and waives in favor of _____
(Name of person receiving waiver)

the rights of the United States in and to said invention in the foreign countries listed below, together with the right to apply for and receive patents for said invention in said countries, subject however to the reservation by the Administrator of an irrevocable, nonexclusive, nontransferable, royalty-free license for the practice of such invention throughout the world by or on behalf of the United States or any foreign Government pursuant to any treaty or agreement with the United States. The countries are as follows:

2. This disclaimer and waiver is conditioned upon the Contractor doing the following:

(A) Preparing without direct cost to the United States Government a United States patent application covering the invention;

(B) Executing or causing to be executed instruments of mesne assignment of the invention (prepared by the Government) in favor of the United States, as represented by the Administrator; and

(C) Forwarding to the Administrator such application for patent, properly executed, for filing in the United States Patent Office, and such instruments of mesne assignment for acceptance by the Administrator.

(D) Obtaining such licenses, or clearances as to secrecy, as may be necessary for exportation of the application for patent to the abovesaid foreign countries and for the filing thereof in such countries.

(E) Filing an application for patent in each of the abovesaid foreign countries not earlier than the filing of the United States application and within (i) nine months from the date the corresponding United States application is filed; (ii) six months from the date permission is granted to file foreign applications where such filing had been prohibited for security reasons; or (iii) such longer periods as may be approved by the Administrator.

(F) Notifying the Administrator of the date of filing the application for patent in each of the abovesaid countries and identifying said applications.

(G) Requiring each instrument granting any license or sublicense to practice said invention in the abovesaid countries to contain a notation of the royalty-free license reserved by the Administrator.

3. This Instrument of Waiver, waiver, and disclaimer is voidable, at the option of the Administrator:

(A) If the Contractor shall have failed to comply with a material condition of the waiver as set forth herein; or

(B) If it is subsequently discovered that the waiver was based upon misrepresentation of a material fact.

4. The Administrator agrees to assign to the Contractor the entire right, title, and interest of the United States in said invention in each of the above-said foreign countries upon notification that the application for patent has been filed or has been prepared and is ready for filing in said foreign country.

Signed at Washington, D.C., this _____ day of _____, 19____.

By direction of the Administrator, National Aeronautics and Space Administration.

_____

The Contractor has caused this instrument to be signed and attested by its duly authorized officers this _____ day of _____, 19____, accepting said instrument with the intent to be legally bound thereby.

_____
(Contractor)

By _____ _____
(Name) (Title)

_____
(Address)

_____
Attest.

Effective date. These regulations shall be effective upon publication in the FEDERAL REGISTER.

T. KEITH GLENNAN,
Administrator.

[F.R. Doc. 59–1919; Filed, Mar. 4, 1959; 8:51 a.m.]

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

PART 1—PATENTS

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PATENT REGULATIONS

PART 1—PATENTS

100 *Scope of part.*—(a) This part prescribes contract clauses and instructions which define and implement the policy of the National Aeronautics and Space Administration (NASA) with respect to—

(i) inventions made in the performance of work under contract with NASA;

(ii) patent infringement liability of the United States resulting from work performed under contract with NASA;

(iii) security requirements covering patent applications containing classified subject matter; and

(iv) patent royalties payable in connection with the performance of contracts with NASA.

(b) The policies, instructions, and contract clauses prescribed by this part 1 are applicable to contracts which are to be performed within the United States, its Territories, its possessions, or Puero Rico. The Office of the General Counsel, NASA, should be consulted concerning the policies, instructions, and contract clauses to be used in contracts other than those specified in the preceding sentence.

101 *Property rights in inventions made in the performance of work under NASA contracts.*—

101.1 *General.*—It is the policy of the National Aeronautics and Space Administration, except as to any invention made in the performance of any work under any contract with NASA of the type described in paragraph 101.2, to pay reasonable compensation for the acquisition of rights in any invention covered by a valid patent issuing thereon and enforceable against the Government. Such rights in "background" patents will not be acquired in contracts for supplies and services except by specific negotiation for such rights, unless the patents and the rights thereunder are listed and priced as a separate contract item. Questions of validity, enforceability, and infringement of patents will be determined by the Office of the General Counsel, NASA. It is also the policy of NASA to refer to the Inventions and Contributions Board for consideration for an award each invention made by an employee of an NASA contractor or subcontractor to which NASA has acquired title and with respect to which an application for patent by NASA has been authorized. The Administrator, upon his own initiative, may make monetary award on any such invention in such amount and upon such terms as he shall determine to be warranted.

101.2 *Use of "property rights in inventions" clause.*—(a) A "property rights in inventions" clause shall be included in every NASA contract [1] or modification thereof which entails technical, scientific, or engineering work of a kind performed in a contract having as one of its purposes (1) the conduct of basic or applied research; (2) the design or development, or manufacture for the first time, of any machine, article of manufacture, or composition of matter to satisfy NASA's specifications or special requirements; or (3) the development of any process or technique for attaining a NASA objective not readily attainable through the practice of a previously developed process or technique; or (4) the testing or experimenting with a machine, process, or technique to determine whether the same is suitable or could be made suitable for a NASA objective. The price of any NASA contract shall in no event be increased merely by reason of the inclusion of a "property rights in inventions" clause in such contract.

(b) The "property rights in inventions" clause (IX–A)[2] shall be used in all contracts for work of the kind described in (a) above, except as otherwise provided in paragraphs 101.6 and 101.7.

101.3 *Contract administration of "property rights in inventions" clause (IX–A).*—The following subparagraphs of this paragraph 101.3 provide interpretations and procedures to be used in the administration of clause IX–A.

(a) The term "invention" is defined in clause IX–A as including a discovery, improvement, or innovation, since each may include an invention susceptible of protection under the U.S. Patent system. The contractor is not required to report every trifling discovery, improvement, or innovation that may be made under a

[1] It is considered that a contract made by another Government agency on behalf of NASA is a "contract of the administration" within the meaning of subsec. 305(a) of the act.

[2] The "Property Rights in Inventions" clause and all other clauses referred to subsequently herein are set forth in appendix A attached to this pt. 1 and are designated by numbers, IX–A, etc.

NASA contract. However, those discoveries, improvements, and innovations which appear to fall within a statutory class of patentable subject matter (see 35 U.S.C. 101 or 171) and which have a reasonable probability of being patentable are required to be reported under paragraph (b) of clause IX–A. Any doubts respecting patentability should be resolved in favor of furnishing the report. It is not necessary that the contractor determine that the invention is patentable prior to furnishing such report.

(b) In complying with the obligation imposed by paragraph (b) of clause IX–A, the contractor may initially furnish to the contracting officer only such technical information as is required for the purpose of identifying the invention and determining its utility in the conduct of aeronautical and space activities. When requested by the contracting officer, the contractor shall prepare and furnish such additional technical descriptions of the invention as will be adequate for ready transposition to patent specification form and for effective prosecution of a patent application.

(c) If the contractor desires to avail itself of the hearing provided by subsection 305(d) of the act before the Board of Patent Interferences with respect to an invention made in the performance of work under a NASA contract containing clause IX–A, the contractor must file a U.S. patent application for the invention in accordance with procedures set forth in paragraphs (d) and (e) of such clause and take the other appropriate actions therein specified.

(d) Contractors will be notified, by an instrument in writing, within 6 months from the date of receipt of written statements described in paragraph (d)(i) of clause IX–A and submitted pursuant to provisioons of paragraphs (d) and (e) of said clause, of the Administrator's determination as to whether the invention was made under the circumstances set forth in paragraphs (1) and (2) of subsection 305(a) of the act. Where the presumption set forth in paragraph (d) of clause IX–A takes effect under any of the conditions prescribed in paragraph (d) or (e) of said clause, the contractor will be notified promptly thereafter by an instrument in writing that the Administrator has made the determination that the invention was made under the circumstances set forth in paragraphs (1) and (2) of subsection 305(a) of the act. Where the contractor has filed, or caused to be filed, a patent application in accordance with the procedure set forth in paragraph (e)(v) of clause IX–A and the written statement specified therein, the contractor will be notified by an instrument in writing, within 90 days after receipt by the Administrator of such written statement of the Administrator's decision as to whether the invention was made under the circumstances of paragraphs (1) and (2) of subsection 305(a) of the act, and, if it was so made, that the Administrator intends to request that the patent be issued to him on behalf of the United States when the Patent Office determines that the invention is patentable.

101.4 *Contracts relating to atomic energy.*—Paragraph (1) of clause IX–A is included for the purpose of determining the disposition of the title to and rights under any application for patents or any patent that may issue on any invention made by employees of the contractor and relating to the production or utilization of special nuclear material or atomic energy within the purview of the Atomic Energy Act, 1946 (U.S.C. 1801–1819) and of 1954, as amended (42 U.S.C. 2011–2296). This paragraph of clause IX–A will become effective as a part of clause IX–A only in those contracts which entail the performance of technical, scientific, or engineering work relating to atomic energy. It is suggested that the schedule of the contract recite whether the contract calls for such work.

101.5 *Short form "property rights in inventions" clause.*—The "property rights in inventions (short form)" clause (IX–B) is authorized for use in lieu of clause IX–A in contracts made with an approved NASA contract from including clause IX–B. Such NASA forms using clause IX–B will generally be limited to use in contracts with nonprofit organizations for basic and applied research which do not call for the delivery to the Government of supplies, models, or prototypes.

101.6 *Patent rights under contracts for personal services.*—The "property rights in inventions" clause (IX–C) shall be used in contracts entered into with an individual for personal services to be performed by that individual under Government supervision and paid for on a time basis.

101.7. *Patent rights under product improvement programs or independent research programs.*—Where NASA under its established procedures provides, as an item in the computation of overhead, financial support to (i) a contractor's

product improvement program, or (ii) a contractor's independent research program, the inventions resulting from such programs are not subject to the "property rights in inventions" clause IX–A, B, or C merely by virtue of the provisions of such financial support. Clause IX–D may be included in the schedule of a contract wherein NASA is providing such support to the contractor's product improvement program or independent research program.

102 *Followup of property rights in inventions.*—Appropriate systems of followup in connection with the administration of contracts of NASA containing a "property rights in inventions" clause will be maintained by the Office of General Counsel, NASA, in order that (i) invention in which the Government may have an interest may be properly identified, (ii) suitable and necessary steps may be taken to protect the Government's interest in such inventions, and (iii) formal agreements may be obtained evidencing the Government's interest.

103 *Authorization and consent.*—(a) Under 28 U.S.C. 1498, any suit for infringement of a patent based on the manufacture or use of a patented invention for the Government by a contractor or by a subcontractor (including lower-tier subcontractors) can be maintained only against the Government in the Court of Claims, and not against the contractor or subcontractor, in those cases where the Government has authorized or consented to the manufacture or use of the patented invention. Accordingly, in order that work by a contractor or subcontractor under a Government contract may not be enjoined by reason of patent infringement, authorization and consent shall be given as herein provided. The "authorization and consent" clause (IX–E) may be included in any contract for supplies, including construction work.

(b) Greater latitude in the use of patented inventions is to be allowed in a contract for experimental, developmental, or research work than in a contract for supplies. The "authorization and consent" clause (IX–F) shall be included in all contracts calling exclusively for experimental, developmental, or research work, except that it need not be included in contracts made with an approved NASA contract form which omits the clause.

104 *Patent indemnification of Government by contractor.*—(a) NASA's mission is directed to (i) research into the solution of problems of flight within and outside the atmosphere, (ii) the development, construction, testing, and operation for research purposes of aeronautical and space vehicles, and (iii) such other activities as may be required for the exploration of space. Since a patent indemnity clause is not appropriate in contracts for experimental, development, or research work, such a clause is not included in this regulation.

(b) In cases, however, where it is known that an item being procured is protected by a U.S. patent or patents, the inclusion of a patent indemnity clause may be appropriate. In such case, where the patent owner informs a prospective bidder or otherwise contends that the item being procured would infringe his patent or patents, the question of patent indemnification should be referred promptly to the Office of the General Counsel, NASA.

105 *Notice and assistance.*—The Government should be notified by the contractor of all claims of infringement in connection with the performance of a contract which comes to the contractor's attention, especially where the Government has given its authorization and consent for the use and manufacture in the performance of the contract of any patented invention or where the contract calls for the delivery to the Government of supplies, models, or prototypes. The contractor should also assist the Government, to the extent of evidence and information in the possession of the contractor, in connection with any suit against the Government, or any claim against the Government made before suit has been instituted, on account of any alleged patent infringement arising out of or resulting from the performance of the contract. Accordingly, the "notice and assistance regarding patent infringement" clause (IX–G) shall be included in all contracts in excess of $10,000 for supplies, construction, or experimental, developmental, or research work, provided that such clause need not be included in contracts made with an approved NASA contract form which omits the clause.

106 *Processing of infringement claims.*—Subsection 203(b)(3) of the National Aeronautics and Space Act of 1958 authorizes the Administrator "to acquire (by purchase, lease, condemnation, or otherwise), * * * real or personal property (including patents, or any interest therein) as the Administrator deems necessary * * *." This authority is applicable to the settlement of infringement claims only in the instance of a continuing or planned future infringement. Where, however, a claim is for past infringement only, the cited section of the act does not provide authority for the settlement of such claims. Accordingly,

no claim against the Administration for past use or manufacture by or for the Government of an invention covered by a U.S. patent will be considered for settlement unless it is determined that the alleged infringement is continuing or that future use or manufacture of the patented invention is foreseeable. Any such claim should be addressed to the Office of the General Counsel, NASA, and furnish information—

(i) identifying the U.S. patent or application for U.S. patent;

(ii) the interests of the claimant; and

(iii) the acts alleged to constitute the unlicensed use or manufacture of the patented invention.

The claimant should also state that his claim is not based solely upon past unlicensed use or manufacture of the patented invention.

107 *Classified contracts.*—Unauthorized disclosure of classified subject matter, whether in patent applications or resulting from an issuance of a patent, may be a violation of 18 U.S.C. 791 et seq. (espionage and censorship) and related statutes and may be contrary to the interest of national security. Accordingly, the "Filing of Patent Applications" clause (IX–H) shall be included in every classified contract and in every unclassified contract which covers or is likely to cover classified subject matter.

108 *Payment of royalties.*—The Government has acquired license and other rights under a large number of inventions as the result of Government-sponsored research and development. In order that the Government may determine whether the approval as an item of allowable cost of the payment of royalties by the contractor under license agreement is consistent with the rights which the Government has acquired, these payments of royalties by the contractor are allowable only to the extent authorized by the contracting officer. Accordingly, the "Payment of Royalties" clause (IX–I) shall be included in all cost reimbursement type contracts for services or supplies.

IX–B—PRESCRIBED BY PARAGRAPH 101.5

PROPERTY RIGHTS IN INVENTIONS (SHORT FORM)

This contract and all subcontracts hereunder are subject to section 305 of the National Aeronautics and Space Act of 1958 relating to property rights in inventions. The term invention includes any invention, discovery, improvement or innovation. The contractor shall furnish to the contracting officer a written report containing full and complete technical information concerning any invention made in the performance of any work under this contract promptly upon the making of such invention and shall require all subcontractors so to do. The contractor agrees to furnish such additional factual information required by NASA concerning the circumstances under which such invention was made, and to take such further steps as are necessary to enable the Administrator, NASA, to file patent applications on any such inventions. Prior to completion of this contract, the contractor shall furnish to NASA a report as to whether or not any inventions of the type referred to herein have been made in the performance of work under this contract.

IX–C—PRESCRIBED BY PARAGRAPH 101.6

PROPERTY RIGHTS IN INVENTIONS (PERSONAL SERVICE CONTRACTS)

(*a*) This contract is subject to section 305 of the National Aeronautics and Space Act of 1958 relating to property rights in inventions. The term invention includes any invention, discovery, improvement or innovation. The contractor shall furnish to the contracting officer a written report containing full and complete technical information concerning any invetion made in the performance of any work under this contract promptly upon the making of such invention. The contractor agrees to furnish such additional factual information required by NASA concerning the circumstances under which such invention was made, and to take such further steps as are necessary to enable the Administrator, NASA, to file patent applications on any such inventions. Prior to completion of this contract, the contractor shall furnish to NASA a report as to whether or not any inventions of the type referred to herein have been made in the performance of work under this contract.

(*b*) With respect to any invention reported or required to be reported under (a) above as to which rights have not been vested in the Government pursuant

to provisions of section 305 of the NASA Act of 1958, the contractor agrees to be bound by all provisions of Executive Order 10096, dated January 23, 1950, and any orders, rules, regulations, or the like issued thereunder.

IX–D—PRESCRIBED BY PARAGRAPH 101.7

CONTRACTORS INDEPENDENT RESEARCH PROGRAMS

Any invention made in the performance of any work by the contractor under the contractor's own product improvement program or the contractor's independent research program, even though supported by an allowance of costs for such program as a part of the overhead costs hereof, will not be subject to the "Property Rights in Inventions" clause of this contract unless said work is identified in writing as being required in the performance of this contract.

IX–E—PRESCRIBED BY PARAGRAPH 103(A)

AUTHORIZATION AND CONSENT

The Government hereby gives its authorization and consent (without prejudice to its rights of indemnification, if such rights are provided for in this contract) for all use and manufacture, in the performance of this contract or any part hereof or any amendment hereto or any subcontract hereunder (including any lower tier subcontract), or any patented invention (i) embodied in the structure or composition of any article the delivery of which is accepted by the Government under this contract, or (ii) utilized in the machinery, tools, or methods the use of which necessarily results from compliance by the contractor or the using subcontractor with (*a*) specifications or written provisions now or hereafter forming a part of this contract, or (*b*) specific written instructions given by the contracting officer directing the manner of performance. The contractor's entire liability to the Government for patent infringement shall be determined solely by the provisions of the indemnity clause, if any, included in the contract, and the Government assumes liability for all other infringement to the extent of the authorization and consent hereinabove granted.

IX–F—PRESCRIBED BY PARAGRAPH 103(B)

AUTHORIZATION AND CONSENT

The Government hereby gives its authorization and consent for all use and manufacture of any patented invention in the performance of this contract or any part hereof or any amendment hereto or any subcontract hereunder (including any lower tier subcontract).

IX-G—PRESCRIBED BY PARAGRAPH 105

NOTICE AND ASSISTANCE REGARDING PATENT INFRINGEMENT

The provisions of this clause shall be applicable only if the amount of this contract exceeds $10,000.

(a) The contractor shall report to the contracting officers, promptly and in reasonable written detail, each notice or claim of patent infringement based on the performance of this contract of which the contractor has knowledge.

(b) In the event of any suit again the Government, or any claim against the Government made before suit has been instituted, on account of any alleged patent infringement arising out of the performance of this contract or out of the use of any supplies furnished or work or services performed hereunder, the contractor shall furnish to the Government, upon request, all evidence and information in possession of the contractor pertaining to such suit or claim. Such evidence and information shall be furnished at the expense of the Government except in those cases in which the contractor has agreed to indemnify the Government against the claim being asserted.

IX-H—PRESCRIBED BY PARAGRAPH 107

FILING OF PATENT APPLICATIONS

(a) Before filing or causing to be filed a patent application disclosing any subject matter of this contract, which subject matter is classified "Secret" or

higher, the contractor shall, citing the 30-day provision below, transmit the proposed application to the contracting officer for determination whether, for reasons of national security, such application should be placed under an order of secrecy or sealed in accordance with the provisions of 35 U.S. Code 181-188 or the issuance of a patent should be otherwise delayed under pertinent statutes or regulations; and the contractor shall observe any instructions of the contracting officer with respect to the manner of delivery of the patent application to the U.S. Patent Office for filing, but the contractor shall not be denied the right to file such patent application. If the contracting officer shall not have given any such instructions within 30-days from the date of mailing or other transmittal of the proposed application, the contractor may file the application.

(b) The contractor shall furnish to the contracting officer, at the time of or prior to the time when the contractor files or causes to be filed a patent application disclosing any subject matter of this contract, which subject matter is classified "Confidential," a copy of such application for determination whether, for reasons of national security, such application should be placed under an order of secrecy or the issuance of a patent should be otherwise delayed under pertinent statutes or regulations.

(c) In filing any patent application coming within the scope of this clause, the contractor shall observe all applicable security regulations covering the transmission of classified subject matter.

IX–I—PRESCRIBED BY PARAGRAPH 108

PAYMENT OF ROYALTIES

Payment by the contractor of any sum for royalties or patent rights not included in the ordinary purchase price of standard commercial supplies shall not constitute items of allowable cost hereunder, unless and until approved by the contracting officer. Reimbursement to the contractor on account of any such payments shall not be construed as an admission by the Government of the enforceability, validity or scope of, or title to any of the patents involved, nor shall any such reimbursement constitute a waiver of any rights or defenses respecting such patents.

Mr. ROUSH. I had one other question I think the gentleman might answer. I probably should know the answer to this, being an attorney. What legal protection do we have against a conspiracy by bidders, on this project, in fixing a price? Do we have any?

Mr. NUNN. You ask what "legal" protection we have?

Mr. ROUSH. Yes.

Mr. NUNN. Let me say our principal protection is practical, rather than legal. Indeed, the invitations I believe were sent to seven contractors. They were very competitive. They wanted the business.

Mr. ROUSH. I could understand if we had that many, but supposing we only had two or perhaps three. I don't like to be an alarmist, but I can see where there is a possibility of conspiracy.

Mr. NUNN. The fundamental answer is that these companies are interested individually in the business that is available, and they are indeed competitive with one another. It is true, on the one hand, that as you reduce the number of competitors the opportunity for conspiracy in a theoretical sense increases. On the other hand, our experience has been that even with only three or four bidders, they have manifested signs of being hotly competitive.

Mr. ROUSH. How many bidders must you have before you will acknowledge or take bids? Supposing you just had one bidder?

Mr. NUNN. If you had only one bidder, then you have a choice either to let the contract to that one bidder, or to back off from the proposed procurement and make an attempt later to find other sources, other people who are interested, in order to develop a competitive atmosphere in which to perfect the procurement.

Our statutes governing us with respect to this sort of thing are all based upon the idea of achieving the maximum amount of competition in both advertised and negotiated procurements.

Mr. ROUSH. In submitting their bids, or possibly in any other manner, do we have any idea as to how much profit these people make on these projects?

Mr. NUNN. Sure.

Dr. SILVERSTEIN. We regulate their profit. A contract of this type for an experimental article is on a cost-plus-a-fixed-fee contract. And the values of the fee for accomplishing the job are set ahead of time in the contract.

Mr. ROUSH. That is all, Mr. Chairman.

Mr. SISK. The gentleman from California?

Mr. MCDONOUGH. No, I have no questions at this time, Mr. Chairman.

Mr. WILCOVE. Is this the lowest bid that was entered—by Rocketdyne?

Mr. NUNN. I believe not.

Mr. MCDONOUGH. You have a responsibility there as well as a low bid.

Mr. WILCOVE. I appreciate that.

Dr. SILVERSTEIN. There are many factors that enter into any bidding evaluation. We always set up first a technical team to evaluate the technical aspects, and a management team to evaluate the management capability. Then on a point system, based on valuation not only of cost, which is one item, but of the whole capability of the organization within the framework that they establish, and they have, for this purpose, to provide us with very detailed information as to their capabilities.

We evaluate the overall contract.

Mr. WILCOVE. In comparison with the seven bidders, as far as the cost is concerned, where do they stand?

Mr. NUNN. I don't have those figures here.

Mr. WILCOVE. Second, third—as far as the cost is concerned?

Mr. NUNN. I just don't recall where they stood in the order of figures. I might point out that you can't really compare the costs estimated by the respective bidders one with another without taking into account the differences between the products that they are offering for the costs that they are citing.

It is these technological differences that Dr. Silverstein is referring to as having been analyzed by a team of engineers and scientists who reviewed each of the submitted proposals from a technical and engineering point of view, as to which the rating system was developed, the objective being to get the best engine utilizing the most desirable engineering principles.

Dr. SILVERSTEIN. There is a grave responsibility here, as you are well aware. If the Government is going to invest this sum of money over a period of 5 years or 4 years, the responsibility evolves upon the contracting agency to be very sure that the thing that they are buying is the thing that they need, that the company that is bidding is truly responsible and able to carry out the job from a management point or view in addition to the technical point of view; so that, it comes down to a very careful piece of study of the whole situation.

No one item can be left out.

Mr. SISK. If counsel will permit me to clarify this a little, as I interpret these so-called bids, essentially they are really not bids. They are actually negotiated proposals in a way, and that was one thing that I wanted to ask you before we left this item.

There is, of course, a difference between what we call cost-plus and cost-plus-fixed-fee contracts, because of what happened during the last war. We heard a lot of criticism about them. I know you are proceeding, not under that type of thing, but under this other.

As I understand, what you in essence require is that these companies present to you proposals that will meet the objectives which you have in mind. Then they come in and submit a proposal.

For example, the military asks for a weapons system. They come in and propose—North American or Douglas or some other company—a weapons system, to fit the needs or objectives of a particular service. There may be a wide difference involved in the costs or the amount of material involved and so on.

Therefore, then, it becomes a task for your team to evaluate what they are actually going to produce to meet the objectives and how well it will meet the objectives compared to what A company or B company or C company may propose.

So it almost becomes a negotiated arrangement rather than what you call a straight bid. Is that not true, Dr. Silverstein?

Dr. SILVERSTEIN. I think you have stated it very accurately.

Mr. SISK. I might say this is not to be critical of questions of counsel because I am very much concerned that every bit of care be used to get the most for the lowest amount of dollars.

Go ahead with your questions. I wanted to get clear in my mind that I understood this procedure.

Mr. WILCOVE. I assume that there were initial bids followed by negotiation after that in the selection of the contractor?

Dr. SILVERSTEIN. There are always negotiations with the successful bidder for minor changes in perhaps his proposal. His proposal might be that best proposal, but it may not meet your objectives 100 percent. So you negotiate a bit to get them exactly the way you would like to have them.

Mr. WILCOVE. I wonder, Mr. Chairman, if in order to get a complete picture, we could have placed in the record the names of the seven bidders and their initial bids?

Dr. SILVERSTEIN. I would suggest, sir, if I may, that perhaps in the line of the true competitive spirit of our national industry that this might not be a good thing to do.

Mr. WILCOVE. Weren't they all made public?

Dr. SILVERSTEIN. Normally the bids are not made public in this way, are they?

Mr. NUNN. That is correct. You see, this was not an advertised procurement, as in the case where you advertise and bids are received and then there is a public opening. This was a negotiated procurement. Proposals were received from, I believe, six companies, in response to invitations to submit proposals sent to seven companies. Those six proposals were considered, not in public, but rather privately by NASA, and analyzed in secret by NASA, and the selection was made without any outside influence from any of the companies and without any publication of any information.

Mr. McDONOUGH. They can be reviewed by the committee but not published in the report.

Mr. SISK. I was going to suggest if counsel felt this might be—and I am inclined to think this certainly should be in line—if you submit them to the committee as confidential data and not necessarily to be spread on the record, so that the committee may have an opportunity to take a look at them.

There will be no objection to that on your part, would there?

Dr. SILVERSTEIN. Not at all.

(The data referred to was subsequently submitted and is now in the committee files.)

Mr. McDONOUGH. The award having been made in this instance, is Rocketdyne privileged to subcontract for materials?

Dr. SILVERSTEIN. They will probably subcontract for more than half of the items. I don't recall exactly the number, but it is in order. Do you recall?

Mr. NUNN. My recollection is that it is less than half they would subcontract for.

Mr. SISK. In line with my comment a little bit ago, will you briefly set forth what is meant by a cost-plus-fixed-fee as compared to the old cost-plus contracts with which we were familiar during the war?

Dr. SILVERSTEIN. The cost-plus-fixed-fee works in this fashion, that when the contract negotiations are completed on the R. & D. phases of the contract that are agreed upon, a fee is set in the amount of some percentage of the overall R. & D. contract cost.

This fee, then, is not changed as a result of any further contract negotiations. This fee is fixed in the contract.

What I am really saying, if it costs more——

Mr. NUNN. I think what Dr. Silverstein is reflecting is the thought processes by means of which the fee is negotiated. There is no percentage figure in the contract. The contract expressly calls for a fee in dollars, and that is the fee that the contractor will earn as a consequence of performing the contract regardless of cost.

Mr. SISK. I think that pretty ably explains it. For example, you know of the many, many charges we had during the war, for example a shipbuilder—and I am just using this purely as an illustration—the more money he spent, the more money he made because of the cost-plus involvement in it. Of course as I understand the procedure here on a cost-plus-fixed-fee, they cannot get by with that sort of procedure.

Dr. SILVERSTEIN. That is correct.

Mr. HYATT. If he spends $110 instead of $102, his fee does not increase.

Mr. WILCOVE. Was the fee based on a percentage profit?

Mr. NUNN. What do you mean, Mr. Wilcove?

Mr. WILCOVE. Was there any attempt made to determine on the size of the profit and then set the fee based on that?

Mr. NUNN. The fee is the profit that the contractor makes.

Mr. WILCOVE. I appreciate that, but what percentage profit is it on the entire contract? Is it a 5 percent profit or 6 percent?

Mr. NUNN. I don't remember what the percentage figure is. On the estimated cost?

Mr. WILCOVE. Yes.

Mr. NUNN. I don't remember what the percentage figure is. That could be calculated simply by dividing.

Mr. WILCOVE. If we don't know what kind of a profit they are making, they could be making a 20 percent profit.

Mr. NUNN. We know what the range is. I would say—when we submit these figures I think we can include this. It's better than my guessing.

Mr. SISK. I was going to say then, Will you submit those and also submit, for the committee, the agreement reached with Rocketdyne so we can take a look at it?

Mr. MCDONOUGH. As I understand it, this is an obligation that we have already entered into.

Dr. SILVERSTEIN. Yes, sir.

Mr. MCDONOUGH. And the additional $30,200,000 over the $10 million of last year is part of the $102 million contract?

Dr. SILVERSTEIN. $30.2 million we have here is part of the $102 million contract.

Mr. SISK. It is just an additional increment against the total cost.

Dr. SIVERSTEIN. Yes.

Mr. MCDONOUGH. Another question: Is NASA the only agency in the Government that has a negotiated contract or understanding with an outside operator to develop a 1-million-pound-thrust engine?

Dr. SILVERSTEIN. Yes. There is no other liquid engine of 1-million pounds of thrust in the national program outside of this engine.

Mr. MCDONOUGH. The Defense Department or ARPA?

Dr. SILVERSTEIN. Nobody else has it. I should say this, I should have said single-barrel engine—that is, a big engine. There is, as you know, the cluster combination of existing engines, 150,000-pound engines, which is now being carried on at ABMA as a large rocket combination. But from the standpoint of a big engine, an engine of this size with a million or a million and a half pounds of thrust in a single combustion barrel, this is the only project.

Mr. SISK. This is the only single-barrel engine that is being developed of this size. The cluster project at Redstone, of course, is using smaller engines.

Dr. SILVERSTEIN. Yes, it uses eight smaller ones.

Mr. SISK. Are there any further questions regarding this item of $30,200,000?

In conclusion, then, Dr. Silverstein, as I understand, NASA has a team monitoring and working right with these people. You have full responsibility to see to it that this money is efficiently spent and efficiently used and that the Government is fully protected in its obligations here in this instance?

Dr. SILVERSTEIN. Yes, sir.

Mr. WILCOVE. Mr. Chairman, if I may, I would like to ask Dr. Silverstein if there is any estimate of the cost of the engines—not the prototype, but after they go into full production. Is there any estimate of the ultimate cost?

Dr. SILVERSTEIN. There have been estimates made. Do you have those at your fingertips?

Mr. HYATT. They are very rough, but roughly $2 million each.

Mr. WILCOVE. $2 million each.

Mr. HYATT. Very rough at this time.

Mr. WILCOVE. Is there any indication whether the Russians are also attempting to build a 1-million-pound-thrust engine?

Dr. SILVERSTEIN. None that I have. No information that I have.

Mr. SISK. If there are no further questions, what is the committee's pleasure with reference to this item? As I say, it is the third largest single item in our portion of the budget here. Without objection, the item will be considered to have the approval of this subcommittee.

All right, Dr. Silverstein, we will proceed then to the next item, which is nuclear rocket engines, where I believe you used about $41½ million, or at least had that appropriation, in 1959 and you are asking for $8 million in fiscal 1960.

Dr. SILVERSTEIN. I think you may recall the presentation that was made in this area by Dr. Rothrock to the full committee. He showed the relationship of the nuclear rocket engine to the chemical powerplants and brought out the step increase in specific impulse associated with the use of the low density, low molecular weight fuels.

In this nuclear rocket program, the reactor part of it, the actual heat source part, is being carried on by the AEC at the Los Alamos Laboratory. They have, as you know, a program that has been in progress for the last several years in which they are developing the reactor part of the system.

It is leading to current tests on what is called a Kiwi-A, and tests later on a unit called the Kiwi-B. We have the part of this program related to providing the tankage, the systems, the pumps, the air frame parts which fit around the reactor and provide propellant for the system, the shielding and all the rest.

We have been supporting the program during this year. We will also continue it next year. They are broken down as you see on page 270 into a series of different items. The breakdown includes first an item for scientific and technical studies. I think you must know that in as advanced a field as nuclear propulsion there are many new technical problems that arise.

The typical problems are these. Here we have a situation with very intense radiation field and we have materials surrounding it that are down to cryogenic temperatures. As we demonstrated for you in the chemical rocket, in order to keep the materials in the walls of the rocket in which the gas temperatures are up to 5,000° Fahrenheit from burning up, we have to feed the propellants back through the tank walls. We call it a regenerative process—regenerative because the fuel passes first through these walls and back into the engine. We run into the situation here where materials are operating at conditions under which they have never operated before—that is, a combination of an intense radiation field and liquid hydrogen temperatures.

We are aware of some of the radiation effects on materials. But at these low temperatures where the molecular activity is slowed down almost to a stop, we don't know what the effects of radiation will be on materials.

So we must make studies. We may find that materials will disintegrate. We simply don't know. We may find nothing. This is one of the problems.

We have unusual heat transfer problems in the rocket. There are very high temperatures, you see, and very thin walls. The problem is the determination of the type of heat transfer packages we need to get the heat out from the inside of the rocket into the cooling medium.

These are the types of things and there are a number of these programs that are included in the scientific and technical studies, the first phase of this program breakdown.

In the second part, the prototype and operational hardware is an item in fiscal 1960 for a million and a half dollars in the Rover project. This is a specific item which is support for the work in the pumps that will be used in the Kiwi–B program development. Here we have a case of pumping a very large quantity of hydrogen. The technology of hydrogen pumping is simply not very far along. There has been some research work done at our Lewis Research Center. Currently, as a part of our Centaur program, we are developing pumps for engines of about, let me say in this open hearing, very much smaller sizes.

With the Kiwi–B reactor, we would be pumping very large quantities of fuel. A whole new pump technology needs to be developed and we are providing that in these funds. We have agreements with the AEC as to the part of this program that we will carry on. We, for example, are to provide the propellants which will be covered by our funds.

The second item here is the nuclear electric power generation for propulsion. Here we have to take the step of going from the heat source, which is the reactor, to the use of the heat to provide a source of power. It means a conversion of the heat into electrical energy by means of a thermodynamic system, and by that I mean an engine system in which we heat a working fluid and pass it through a set of turbines, drive the turbines and an electric generator. These sorts of things were covered in this item.

Specifically we have in mind an extension of the current program which you may have heard of, called the Snap program. The Snap program now provides power of 3 to 4 kilowatts. However, as we move to deep space missions where we want to, say, pass information from a distance of 50 million miles back to the earth, we are going to need rather substantial powers. We will need power also in our manned vehicles for providing life support, life science equipment.

So we need currently to develop power systems which have more capability than 3 to 4 kilowatts. Specifically we need to move toward the development of something almost of 10 times this capability. These funds in this area are specifically directed toward that order—that is, a million and a half dollars for the nuclear electric power generation.

Mr. McDonough. The nuclear rocket engine can only be used if we develop the 1 million pound thrust single chamber, can't it? We can't get it into the air with anything that we have now, can we?

Dr. Silverstein. You could put it in the air now as an experimental object for test, but probably wouldn't without the bigger system because you wouldn't have missions that require it. Our big systems that are coming along in the future are the ones for which we will need the nuclear top stages.

Mr. McDonough. What I am getting at, Mr. Chairman, is this: As we go along, if we haven't yet developed the million-pound-thrust engine, the question may arise whether we should spend as much as $8 million on the nuclear engine until we get further along on the million-pound-thrust engine.

Dr. SILVERSTEIN. May I speak to this for a minute in this sense. We have items here which, I believe all of us must be aware, are long-lead-time items. They are really research and development items; unless you work on them now, you simply don't have them in 6, 8, or 10 years from now. They take a long time. If you visualize, for example, we are creating a reactor here that provides temperatures that are many times higher than we are asking from any of the reactors that are operating now. Our power reactors operate at relatively low temperatures.

Here we are moving up to temperatures that are at least six or seven times as high as those we use in our submarines. You can visualize the technical problems here—corrosion problems, the liquid metal cycles.

There are a fantastic number of them. Either we have to decide we are not interested in providing for the future this advanced capability, or else we have to say that we must begin now to lay the background for its development. The latter is the decision we make, I believe.

Mr. MCDONOUGH. How much different is a nuclear-powered generator for propulsion in the air—how much difference is there in that than the same thing under the sea, under the water?

Dr. SILVERSTEIN. There would be a great deal of difference.

Mr. MCDONOUGH. What are the essential differences?

Dr. SILVERSTEIN. There are differences in the temperature level. The temperature level here will be some three to four times higher for use in space. The reason is this; there is a premium on weight. In order to make these units light enough to fly, you must make them hot. Under water you can use a unit much larger in size and weight than a space engine, and therefore you can let the temperatures drop. The higher the temperature level in a propulsion system, the lighter it gets. You can see why. The fuel is being used more effectively in the thermodynamic process.

Mr. SISK. To what extent, Dr. Silverstein, are you dependent, or is the AEC dependent, on what you do in this program? Maybe I don't make myself clear, but as I understand, the AEC is doing certain work in this field, as you indicated earlier. I am curious to know just how that tie-in is operating, whether you are pretty much dependent on progress which they will make before you can move ahead or vice versa, or does it have any relevancy in the matter at all?

Dr. SILVERSTEIN. We are mutually dependent on each other in the sense that their tests depend on our work on pumps and fuels. Our work depends on their development of the reactor. We have set up a coordinating committee for these engines in which we are taking on certain obligations in the program and they are taking on certain obligations.

So there is a mutual dependence here between us.

Mr. SISK. Are you in a position to say, Dr. Silverstein, how much money AEC is putting into this particular program?

Dr. SILVERSTEIN. Yes, sir. I have the numbers. May I delay giving them to you until I find out whether or not they should be released here?

Mr. SISK. I was going to say, if there is any question about their classification, I would prefer that you hold them at the moment.

Dr. SILVERSTEIN. Certainly, we want to get everything before the public that we possibly can here. On the other hand, I certainly do not want to move in on the AEC with reference to any of their classified information.

However, I think it would be well if the committee had some idea.

(The information requested is as follows:)

The following are the AEC budget figures for the Rover project including operations and facilities construction:

	Million
Fiscal year 1959	$26.5
Fiscal year 1960	19.8

These figures are unclassified in the form shown above. Further breakdown of these figures would be classified.

Mr. SISK. I might say there was some question on this item at our first meeting yesterday afternoon as to whether you were ready to expend in the next year $8 million on this program. This subcommittee, as well as the full committee, is interested in doing everything we can with an eye to future programs. I am sure that is what my colleague from California, Mr. McDonough, had in mind.

We, of course, as already indicated, have to justify these figures on the floor. I realize that you are going to need to start doing a lot of these things, or, at least, basic research in them, if we are going to have them 4, 5, or 10 years from now.

Dr. SILVERSTEIN. There is one further point, Mr. Chairman. Previous to the establishment of NASA, this support work in this program was carried on by the Air Force. It was transferred to our tenancy after the NASA was established.

So in effect we are only continuing work that was in progress carried on by a different group.

Mr. SISK. What were the Air Force's objectives in this program? Did it have something to do with the possibility of putting a motor in an airplane?

Dr. SILVERSTEIN. The initial interest here is an advanced R. & D. project, recognizing the long time interval for development, with possible eventual use in missile systems.

Mr. MCDONOUGH. Then you have taken the whole thing over and they are not working on it any longer?

Dr. SILVERSTEIN. We have taken over the support of this program; yes.

Mr. SISK. As I visualize these figures, actually you are asking for $2 million which will be strictly for studies or basic research. In an attempt to try to get a breakdown clear in my mind, under scientific and technical studies, that money will be devoted primarily to what will be called basic research.

Dr. SILVERSTEIN. Basic research with a bit of applied research in it—applied research such as a study of possible radiator configurations that might be used. These I would call applied. The basic studies will be more along the lines of the effects of radiation on materials at very low temperatures.

Mr. SISK. The $5½ million actually is money for hardware. Is that the way you visualize it?

Dr. SILVERSTEIN. That is a very good statement.

Mr. SISK. Is it the feeling of your people that the hardware is absolutely essential to the studies?

Dr. SILVERSTEIN. I think it is absolutely essential to move this field along currently and provide the background of hardware needed for study. In the hardware area, some of these items will come along a little more rapidly than the rocket. That is, the power systems might come along much more rapidly. They may be available in a shorter time.

Mr. SISK. The gentleman from Indiana.

Mr. ROUSH. In this area, once a reactor is used, can it be used again?

Dr. SILVERSTEIN. Yes, sir. For example, in the power area, these reactors may stay in use for rather long periods of time.

Mr. ROUSH. I was in Nevada last week and saw this reactor. I had the impression that they were going to tear that thing apart piece by piece and bolt by bolt and—well, I thought it was not being used again.

Dr. SILVERSTEIN. The one you saw will not be used again. This is the nuclear rocket application, but in a nuclear power application you will be able to use them again. There is a difference. The nuclear rocket normally would go out into space and it would stay there. It might be in use for a period of 2 or 3 years, but it would not be reused after that. In fact, it would be left there.

Mr. ROUSH. I was thinking more in terms of testing these things.

Dr. SILVERSTEIN. During a given test period, the test may extend over a period of 6 months or a year, after which, in all probability, all would be learned in this program that would be desirable to be learned and you would move on to the next prototype.

Mr. SISK. Under your supplies, equipment, repairs, and alterations on the Rover rocket, I see you are requesting no money on that. Is there any particular reason why there is no need there for that? Is someone else picking up the tab? Within the bounds of what you can say in open session, will you comment on the Rover project as it is tied to this?

I think it would be well if you would comment a little bit on this, because many of us have been rather concerned about Rover. I, for one, was frankly somewhat critical last year because I felt the Rover project was not being pushed as fast or as hard as it should be. So whether I was right or wrong—maybe I was wrong—I would like to hear your comment on that because, apparently, it is a part of this overall program.

Dr. SILVERSTEIN. Our feeling, and I am sure that of Mr. Bradbury, who operates the Los Alamos Laboratory, because I have been in quite close touch with him, is that here we have a project that is essentially a long leadtime R. & D. operation that needs to be pursued in this way until such time as we clearly see the end point, after which we would like to move very aggressively toward building final hardware.

Our support of this and also the work going on at Los Alamos is directed in the same way. The first application of a nuclear rocket will probably be a space application—that is, as an upper stage of a booster vehicle that will take it into space, after which the nuclear rocket stage will be used. Currently, I think the work in Rover is going along quite well at about the pace that I think this budget and the AEC budget together require. I, personally, would not like to see the thing given the wrong emphasis at the present time because I con-

sider the proper emphasis to be an R. & D. emphasis. As we move along and see how this is going, I think we will tell you when we come to the point where it needs the real push to provide the operational hardware.

Mr. McDonough. What is the purpose of Rover?

Dr. Silverstein. It would be initially used as an upper stage of a space vehicle.

Mr. McDonough. You mean for a long period——

Dr. Silverstein. For long periods of time and for high efficiency.

Mr. Sisk. If my colleague will yield, I do not know whether he remembers, but we had a gentleman before the select committee last year from the Livermore Laboratories who was very much concerned about the Rover project, the ion theories and so on. I have in mind some of the comments he made at that time and also some conversations I had with him I believe before or after, possibly. That was one of the reasons for my interest in this Rover project as I indicated earlier.

Mr. McDonough. Does Rover depend upon the million-pound thrust single chamber?

Dr. Silverstein. To answer this question, I have to back up a bit and say that not in its development, but in its final use, it will depend on using a large engine to take it up into orbit initially, after which it will perform as a powerplant. But in its development phase it does not depend on the million-pound rocket.

Mr. McDonough. Of course, I can understand that. In its development stage, its true operation will depend upon how it performs after it is put into space.

Dr. Silverstein. To a certain extent.

Mr. McDonough. Can you anticipate what the conditions will be after it is thrust into space in your R. & D. development?

Dr. Silverstein. Generally, yes. What we would consider to be a mission here would be to boost the nuclear rocket stage into, say, a 500-mile orbit, after which you would turn on the nuclear rocket, which we may call a space engine, and accelerate the vehicle then on a path out further into space toward a planet or the moon.

In this mission, the nuclear rocket does not boost from the ground but takes over after you are in orbit.

Mr. McDonough. It has facility for landing on the planet?

Dr. Silverstein. It could be used for that, yes, sir.

Mr. Sisk. Is the money here requested all the money that will be going into the Rover project outside AEC's participation?

Dr. Silverstein. Yes, sir.

Mr. Sisk. And you are going to furnish for the benefit of the committee the figures, at least so we can see them, relative to what AEC is actually putting into this program?

Dr. Silverstein. Yes, sir.

Mr. McDonough. Under each one of these items I see you have space nuclear rockets, scientific technical studies on your prototype, and your operations and your supplies and equipment. How far has that progressed up to the present time?

Dr. Silverstein. This is the support for the Kiwi A and Kiwi B program in its advanced phase. The breakdown we have here just shows the different types of expenditures on the program.

Mr. SISK. There are, as I understand, certain contracts with laboratories, one of which I think I mentioned. But there is a substantial part of this, though, that is so-called inhouse; the basic research is what you term to be inhouse, is it not?

Dr. SILVERSTEIN. There will be perhaps no more than one-eighth of this inhouse, of the total of the $8 million.

Mr. SISK. The balance of it will be contracted out to various universities and laboratories, is that correct?

Dr. SILVERSTEIN. Yes, sir.

Mr. MCDONOUGH. Have you any obligations on this program at the present time?

Dr. SILVERSTEIN. We have some obligations. We have a number of pending commitments in this area, not using 1960 funds, but 1959 funds.

Mr. SISK. Basically you actually have no contractural obligations involving the $8 million.

Dr. SILVERSTEIN. That is right, sir; no 1960 obligations.

Mr. SISK. But in accordance with the studies that are progressing, if you do not get the $8 million, those studies and that research will of course come to a grinding halt. Is that basically true?

Dr. SILVERSTEIN. Yes. We have commitments in the sense we have made agreements with AEC on our part of the support. These have not arrived at the contractual stage as yet, but they are nevertheless moral commitments to move the program along.

Mr. SISK. Are there any further questions?

Mr. WILCOVE. Doctor, when do you expect your first test to take place on your Kiwi?

Dr. SILVERSTEIN. I am not sure whether that is information I should release here.

Mr. SISK. The Chair might say that based on the position taken by these gentlemen and the information that we have and our desire to proceed with a balanced program, that probably the figures are justified. I realize that there have been some questions and I would like to hear some comments from my colleagues from both Indiana and California as to what they feel with reference to this item before we proceed.

Mr. MCDONOUGH. Of course it is difficult for a layman to dispute a scientist on what he needs to carry on a program. My opinions are largely based upon the practical operation of some of these projects. I can see where Rover is one of the more remote projects as far as its actual operation is concerned, compared to a satellite for reconnaisance or weather or communications. For that reason I do not want to say that the amount of money you are asking for under various operations here is not needed, but I want a frank statement from you as to whether there is any item under this particular program that we could reduce without injuring your program to any extent? We are looking to a point where we are going to have to, as the chairman said, justify this not only to the whole committee but on the floor of the House and to the average lay Member of the Congress. There are going to be a lot of questions asked that probably we do not have the answers to.

I see the next item we are going to consider is the space engines. Are nuclear rocket engines not space engines also?

Dr. SILVERSTEIN. Yes. There is a difference here in the sense that we have separated the chemical type of engines from the electrical. Whether this in fact is a good separation, I do not know. It could be combined and maybe should have been combined, but there is that difference. In discussing the space engines I will bring it out.

In answer to your question, if you would like me to answer it, I would say that I consider this program to be a rockbottom plan. There are many people who would feel that this program is not adequate to meet the needs that lie ahead. I feel sure that they would be critical of our position in asking only for this amount. There are enthusiasts—I believe you discussed some of these people a few minutes ago—who, I am sure, would feel our approach is inadequate and these are people who are well qualified.

It is our sound judgment that this is a rockbottom program. We have not attempted to carry this program beyond the point of making sure that as we move along in this program, overall space program, that we are taking a good sound look at what the future might require and whether this country is to be put in the place of being a leader in the space field. I would say, in my judgment, that this is a sound program.

Mr. SISK. If my colleague will yield to the Chair, if there are further questions on this what we could do, certainly, without any reflection on the program, is to pass this over to the next section which Dr. Silverstein says is connected with the nuclear engine section also. We can go ahead then and discuss the space engines in the next section.

Mr. DCDONOUGH. That is all right with me.

Mr. SISK. Without objection, then, we will simply pass over any final action as to a recommendation on the nuclear rocket engines for the moment and move on to space engines.

I might say before Dr. Silverstein gives us the information, that the Chair would like very much to complete the space propulsion technology section before we adjourn. I don't know whether we are going to be able to do it. The hour is almost 12 now.

Mr. MCDONOUGH. We can stay until 12:30.

Mr. SISK. If we can complete this, it would be very fine. It would be a good stopping place. So unless there is objection, we will proceed. So, Dr. Silverstein, please discuss this space engine project for which, I believe you are asking $3 million this year compared to $300,000 in 1959.

Dr. SILVERSTEIN. Yes, sir. I think you may recall again that Dr. Rothrock discussed this the other day and pointed out that, by use of what are called nuclear electric systems, we can achieve a specific impulse in the order of 10,000 to 20,000 as compared to 300 for existing chemical rockets, 435 from fluorine-hydrogen, and about 1,200 for the nuclear rocket.

He also pointed out that they involve the use of very heavy machinery to produce this electric power, and that there needs to be, therefore, judgment used in what system you come up with.

What we are asking for here in 1960 are funds to carry on the basic research and development needed to enable us to find out what the problems are in this area, how they can be solved, and what type of equipment is needed.

Basically there are a number of systems here that need to be looked at. You have to first have a source of heat. This source of heat can either be solar heat from the sun, or it can be nuclear. You take the heat and you heat up a working fluid such as a liquid metal. You expand it through a turbine. You drive an electrical generator. You take the electric power you get here and you put it into an accelerator of one form or another. These accelerators come under different names. It could be what we call a plasma accelerator or it could be an ion accelerator.

Each of these pieces of the system I have mentioned have many, many research problems. We have to find out, for example, what these accelerators look like. There are a number of restrictions on them such as taking care of space charges that are formed behind them and arrangements for buildup of the unit so that we, in fact, can get the required thrust within the size of the unit that can be used.

We have to determine whether, in fact, we are interested in these plasmic accelerators or ion accelerators. This is basic research. There is a great deal of interest in this country in these very advanced engines right now. Exactly when in the future they are going to be used, in fact whether they are going to be used, I think still is a good question. But again we are doing the basic research and development here to find out.

If we do this work and do it properly in the future, I think we will save large amounts of money because we will properly have a background for evaluating things that come.

It is the failure to do this work really that is a source of waste. If you do the work initially and get a good solid footing, you can then move into the more expensive programs on a good sound base.

Mr. SISK. The Chair might say he was much impressed with Dr. Rothrock's presentation the other day on this program. Certainly, as a layman who knows nothing about what actually is involved here, it would seem to me this probably would be a minimum program in a field which could have great possibilities in the future. Are there any questions by members of the subcommittee with reference to space engines?

Counsel?

Without objection, then, the $3 million item for space engines will be considered as recommended by the subcommittee.

We will move on then to the last item in this section, which has to do with auxiliary power units, again an item of $3 million.

Dr. SILVERSTEIN. In the the auxiliary power units we have asked for $3 million, which is the fund required again in a field which is going in the future to require, I believe, rather substantial expenditures. We all know that when we get these space vehicles up they are going to require power. The question is where does this power come from? I mentioned earlier in our discussions of the nuclear program that one source of energy is the nuclear source. Another source is the sun.

You know that we have already successfully used solar cells for making power out of the sun's heat. These have been quite successful. However, there is a great deal of work to be done in developments in this area. The efficiencies that we get with these cells are nowhere near the values that can be reached according to theory. A great deal of scientific and basic technical work needs to be done to increase our capabilities of getting power from the sun.

Frankly, in this area I think there are great gains to be made for the future not only in space but for applications other than in space. This is a basic field of technology which I think may turn out to be what I call one of the side gains that we make in any research and development field when we push it properly.

What we are asking for here is basic work, scientific and technical studies, on the cells themselves and on the methods for taking power from them. We are moving ahead to develop prototype operational hardware using these cells that currently exist and other improvements as they come along, and then certain small amounts of money for supplies and equipment to use with the operational hardware.

I feel myself that this program as we have shown it here, compared with its importance to the program and to the whole future use of power from the sun, may not be high enough. I think this is an area we may not have hit hard enough.

Mr. SISK. I was going to suggest that, based again on the presentation made the other day to the full committee on the need and the absolute necessity of auxiliary power units if and when we get into space, or when we get into space—eliminate the "if" because I am sure we are going to do this—that auxiliary power units are essential. I am actually wondering whether enough effort is being used in this field because certainly a man is not going to be able to exist up there without an auxiliary power unit.

Dr. SILVERSTEIN. You are exactly right. This is a good question. It is one that has bothered me, as to whether or not we have put as much emphasis in here as we probably should have.

The need for auxiliary power is unquestionably going to be a limiting factor in the use of space vehicles. Without it we simply cannot live aboard.

Mr. SISK. That is the point as I see it. How many people—thinking of numbers here, if you have any figures on it—how many people actually will be involved in this program for 1960 under this $3 million program?

Dr. SILVERSTEIN. I would say in our research and development field we can use a number something like $30,000 a man-year, including the man's salary and all the supporting equipment he requires to do R. & D. If you divide that out, you will find the number comes out to be something like 100 men.

Mr. MCDONOUGH. On your auxiliary power units, do you have some units perfected or almost near perfection in connection with your Mercury project?

Dr. SILVERSTEIN. No. The Mercury project in itself will not use solar power sources.

Mr. MCDONOUGH. The auxiliary power units you are talking about are solar powered?

Dr. SILVERSTEIN. In this area of the work. We had some back in the nuclear development I mentioned which are also important. These are the two sources of power that have a long-time capability. Batteries are, of course, used currently in our satellites, but the batteries have a short life. For example, you have operating lives of the order of 2 to 3 weeks if you depend upon batteries. The Vanguard I satellite, of course, is up there and is still radiating and we are still picking signals up from it. It has solar cells. It is a satellite that is still radiating after all this period of time.

Mr. McDonough. Will you use any auxiliary power units on the Mercury project?

Dr. Silverstein. On Mercury we will have to have some auxiliary power, but it will not be from this type of machinery. It is just a short time flight.

Mr. McDonough. What source of power will you use there?

Dr. Silverstein. Largely battery. The initial flight of Mercury is only 3½ hours.

Mr. Sisk. That, of course, brings up the point I was making. We just cannot, of course, depend on batteries on any long-range program, even for a flight to the moon, in my opinion. Once you perfect a manned vehicle for a soft landing on the moon—certainly we expect to bring the occupants back or we will not send them out there. I would think you are going to need an auxiliary power unit, something to depend on besides batteries even on a trip of that type, would you not?

Dr. Silverstein. We may very well have to.

Mr. Sisk. Does counsel have any questions with reference to this auxiliary power unit program?

Mr. Wilcove. Doctor, do you have any estimate on how much it will cost to obtain a workable auxiliary power unit, an operational one? The ultimate cost of the program?

Dr. Silverstein. I do not have. The reason is that so much of this work is in such an early stage of research that we really are not able to estimate too far ahead. It depends a good deal on how this work comes out. If we have some breakthroughs in the work that show us the way to get at these things more readily, costs will come down. So I really do not have any good sound numbers here that I could give you.

Mr. Wilcove. The question always arises when you are starting a new program as to what the ultimate cost will be. I am sure it will be raised again. It might not be a bad idea to make some kind of a study on that.

Dr. Silverstein. We can. I do not know really how valuable a study could be at this moment. I could make a study. I would not want to stand behind it too far because it is an early stage for these things. Currently solar cells are quite expensive because of the methods of manufacture. They are quite expensive.

I hope that we can find ways of reducing their costs sharply. This is again, as I say, part of the things that will come out of a good study.

Mr. Sisk. In these auxiliary power units, of course, there is going to be a great requirement, as I see it, for auxiliary power. For example, when you put a vehicle out there, you are going to have to have auxiliary power to control it, to change directional flight, plus the things that are going to be necessary for men to survive.

It just seems to me that looking toward any space flight this is certainly one of the most valuable parts of the program. I, too, in line with what counsel said, think we are going to be asked these questions. What are we committing ourselves to in the long range. Frankly, on many of these programs the only answer I would have for that at the present time is "I just do not know." We would like to have as much response as we could in many instances.

Dr. SILVERSTEIN. I would like to call your attention on page 270 to this business of maneuvering in space is a very important element. In our nuclear program this item I mentioned—the increase in the capability by about 10 times of this Snap unit of which you probably have heard, an item of a million and a half dollars in the nuclear program—is exactly aimed at the point you made, at this problem of maneuvering from one orbit to the other.

Mr. SISK. This is going back to one provision we passed over.

Dr. SILVERSTEIN. Yes. I mentioned this. I may not have made this point at the time. Since you brought the point up, I thought I should mention it.

Mr. SISK. Actually, the last three of these items here have to do with nuclear rocket engines, space engines, and auxiliary power engines. To some extent, a breakthrough here could, let us say, go a long way toward solving the multitude of problems involved in this whole field. So to some extent these three items are pretty closely knit together, are they not?

Dr. SILVERSTEIN. They are, and really it is work in this area that really establishes your future capability. Without this type of work (for example if we would face some 4 or 5 years from now these problems and find that there is an operational need which we see quite clearly now) the costs of a program would be tremendously expensive because it would require then a push for development before you have in fact laid down research properly.

Mr. SISK. It would be a crash program. You do not consider at the present time that these are crash programs?

Dr. SILVERSTEIN. No. These are initial programs to develop the technology and to avoid the need for a crash program at a later time, because the crash programs are the ones that are expensive.

Mr. SISK. Are there any further questions?

Mr. WILCOVE. May I ask, Doctor, if you plan to make some kind of an estimate that we could have for the record as to the ultimate cost of the auxiliary power unit?

Dr. SILVERSTEIN. I will do this for you, although I feel that you should accept my estimate with a great deal of caution.

Mr. WILCOVE. I am sure it will be the best one available, though.

Mr. SISK. We appreciate your honesty in this matter, Dr. Silverstein.

(The information requested is as follows:)

Due to the fact that at this stage our primary need is for extensive research work on the auxiliary power unit, it would be misleading and rather problematical to offer an estimate of the ultimate cost for bringing the unit into existence. When studies are completed of the necessary research work which will lead to the development of the program, the National Aeronautics and Space Administration will be able to supply the requested information.

Mr. MCDONOUGH. Will most of the work under that particular item in this budget, auxiliary power units, be in the department itself? Are you contracting any of that?

Dr. SILVERSTEIN. We will contract for a large percent of this effort.

Mr. SISK. Any further discussion?

Without objection, the $3 million item in auxiliary power units will be considered as having been recommended.

That completes the first of the four major subheadings here with the exception of the $8 million item under nuclear rocket engines

which we will probably bring up for further discussion at our next meeting.

I would like to ask unanimous consent of my colleagues here to quickly return to the 1-million-pound-thrust chamber engine for one question, if I might, Dr. Silverstein.

In view of the fact that ABMA has assumed the responsibility for the cluster program, was there any consideration by ABMA with relation to the development of the 1-million-pound single barrel engine?

Dr. SILVERSTEIN. No, sir. ABMA is not an engine development organization. They are a vehicle group.

Mr. SISK. I realize that. They, of course, contract out. I believe, having seen the figures, that practically 90 percent of their work is contracted out. But they do a certain amount of basic teamwork there. Dr Wernher von Braun does a certain amount of the basic studies and monitoring the program and more or less program management, and then, of course, contracts out various items of materiel, hardware, and other things. I simply for the record feel that it would be well if you had a statement on this, whether there was any consideration given with reference to this particular project where they are concerned.

Dr. SILVERSTEIN. The technical management of this program is actually going to be done by a team of experts drawn largely from our Lewis Research Center, who have followed the liquid rocket engines for a long time, and from WADC—Wright Air Development Center—in the Air Force, who initiated early work in the large rocket development area such as the 150,000-pound rockets and some of the rockets that are currently used in our booster program.

ABMA in all of their rocket work, for example in the Jupiter, the Juno, and in this clustered rocket, have simply purchased rockets from existing engine manufacturers, and have put them into their vehicles. Basically they are not propulsion people in the same sense that, say, our Lewis Laboratory people are or the Wright Air Development Centers.

Mr. SISK. Thank you, Dr. Silverstein.

Mr. MCDONOUGH. Mr. Chairman, just another question. On the development of the million pound thrust engine, is there any other effort underway, outside of the operation that is now being performed by Rocketdyne? Is there any private operator that is attempting to develop such an engine?

Dr. SILVERSTEIN. Not to my knowledge. Certainly this would be a costly venture and without support from one Government organization or another he could not carry it very far.

Mr. MCDONOUGH. Is there any private operator developing any component part of it outside of the contract we have with Rocketdyne?

Dr. SILVERSTEIN. I am sure Rocketdyne is subcontracting with many corporations—but I am not sure this is getting at your question, is it?

Mr. MCDONOUGH. In other words, the million-pound-thrust single-chamber engine, then, is solely being developed under a contract between you and Rocketdyne, as far as you know, in the United States?

Dr. SILVERSTEIN. Yes, with a great deal of subcontracting by Rocketdyne to other companies for components and parts.

Mr. McDonough. Under the parent contract?

Dr. Silverstein. Under the parent contract, yes.

Mr. Sisk. I believe, counsel, you have a question?

Mr. Wilcove. Yes. What power thrust are they trying to achieve at Huntsville? Was it 600,000 pounds?

Dr. Silverstein. With the clustered rocket?

Mr. Wilcove. Yes.

Dr. Silverstein. The clustered rocket is made up of eight rockets which currently have a thrust of 150,000 pounds, leading to a 1,200,000 pounds in the combination. It is expected that the thrust of each rocket engine will increase to about 165,000 pounds in a reasonably short development period, after which the thrust of this combination would equal 1,320,000 pounds. There may be further development in the future.

Mr. Wilcove. Actually, it would approximate the total thrust of the single engine, about a million and a half?

Dr. Silverstein. It would. I think what we must remember here, our capability for building this exists because we have a 150,000-pound rocket, and we have put them together now to form the combination. Our capability for building increases in the future. For example, we showed in our Nova vehicle, again, a grouping of the 1½-million-pound engines to form 6 million pounds of thrust. That is how you develop the capability—by grouping rockets of a certain size to the greater capability.

Mr. Wilcove. Is there any thought eventually of building a larger engine than a 1 million pound single thrust engine?

Dr. Silverstein. Currently, there is not. How things will move in the future I think none of us really know. Our thinking here has not gone beyond the single-barrel 1½-million-pound rocket. As this engine moves along and as we get appreciation for its problems, we will know better.

There is always a worry about extrapolating too far. You never want to extrapolate to the next step until you know enough about the step you are taking. We have made mistakes in the past.

Mr. Wilcove. Thank you, Mr. Chairman.

Mr. McDonough. Is this a classified question: What is the highest single-chamber thrust engine we have at the present time?

Dr. Silverstein. The highest single-chambered thrust we have currently that could be called a production chamber—and I think it is classified. I had better not discuss that.

Mr. Sisk. Are there any further questions? The Chair rather hesitates to ask the subcommittee to try to meet again this afternoon. We originally thought that because of the request of the full committee for expedited action, perhaps we would try to meet. But this being Friday afternoon, I know all of you are in the same position I am, you have, probably, a lot of things on your desks. I was wondering what your attitude would be with reference to us not meeting this afternoon and meeting instead at 10 o'clock Monday morning?

Mr. Roush. That suits me just fine.

Mr. McDonough. All right.

Mr. Sisk. As I say, I will be here this afternoon if you feel we should do it and if you would like to do so. I just feel there is a limit to just how fast we can go.

Mr. McDONOUGH. I yield to Mr. Roush.

Mr. ROUSH. I would prefer meeting Monday morning.

Mr. SISK. With that understanding, then, the committee will reconvene at 10 o'clock Monday morning here in this room. Either we will meet in this room at 10 o'clock Monday morning, or the location will be given to you at a later time.

We want to thank the witnesses. Dr. Silverstein and the other people here this morning have done a very good job. We appreciate that very much.

I understand we will have you people before us again Monday morning.

With that, the committee stands adjourned.

(Whereupon, at 12:25 p.m., the subcommittee was adjourned, to reconvene at 10 a.m., Monday, April 27, 1959.)

1960 NASA AUTHORIZATION

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCES AND ASTRONAUTICS,
SUBCOMMITTEE ON SPACE PROBLEMS AND
LIFE SCIENCES (SUBCOMMITTEE NO. 4),
Washington, D.C. Monday, April 27, 1959.

The subcommittee met, pursuant to adjournment, at 10 a.m., in room B–214, New House Office Building, the Honorable B. F. Sisk, chairman of the subcommittee, presiding.

Mr. SISK. The subcommittee will come to order.

Gentlemen, Mr. Riehlman is unable to be present, but has a representative of his office here. The gentleman from Indiana is here so we will proceed. I believe the gentleman from California, Mr. McDonough, will be coming in here shortly according to the information we have.

I believe at our last meeting we completed the discussion of the items under the "Space propulsion technology," and as I recall, we had approved the item on solid propellant rockets for $3 million, the high-energy-propellant rockets for $5 million, and the 1-million-pound thrust single-chamber engine for $30,200,000.

As the Chair recalls, we passed over the item for nuclear rocket engines which represents the sum of $8 million. We approved the space engines for $3 million, auxiliary power units for $3 million, and, at that time, adjourned our hearings until this morning.

So, our first subhead this morning will be space systems technology, and the first item is "Advanced vehicle systems" for $4,500,000. Dr. Silverstein, we are very happy to have you back with us this morning and will appreciate any comments that you have to make on advanced vehicle systems.

Dr. SILVERSTEIN. Mr. Chairman, this item is for the funds used in development of new vehicular systems. I think you will recall in our earlier presentation that we showed a picture of what we called our Nova vehicle. This is a vehicle which used a cluster of four-1½-million-pound rockets to provide the thrust.

As a part of this system, we have the tankage and fuel systems for this first stage which we are currently expecting to start design and study of. As you well know, in a system of this type the engines form the long leadtime item. So we have entered into contracts for the engines first.

In the meantime great savings can be made in the final design if we carry along preliminary studies of its design to provide time to the designers for very careful analysis, a very careful investigation of the structures and the arrangements to be used in the final vehicle.

Further, in this same vehicle, we showed an upper stage using hydrogen and oxygen as fuel, with thrust around 100,000 pounds.

Here again we need to initiate the stage studies that are required for the final design. The funds we show here, then, are in support of these objects.

Mr. SISK. Actually, so far as hardware, Dr. Silverstein, there is no particular hardware involved in this budget, is that right? The moneys, as I understand it, here are primarily simply devoted to studies, both technical and scientific.

Dr. SILVERSTEIN. Yes, sir. The only hardware that might be involved here would be in model studies of structures or other components that might be a part of the technical studies.

Mr. SISK. Is the work on this particular system being contracted out, or is most of that in-house?

Dr. SILVERSTEIN. This work will be contracted, sir. There will be competition for preliminary design studies.

Mr. SISK. Nothing has been committed on this so far?

Dr. SILVERSTEIN. Not as yet, sir.

Mr. SISK. What was the $500,000 used for in the 1959 budget?

Dr. SILVERSTEIN. These funds are not as yet committed. They will be before the end of the current fiscal year. We have had people on our own staff initially studying the area into which this money will go, and we are getting ready in the next month or two to initiate these studies.

Mr. SISK. So that actually, you will have, you might say, the $2 million to spend on this program in fiscal 1960, is that correct?

Dr. SILVERSTEIN. Yes, sir. These studies will probably extend over into 1961. In other words, there will be a continuing study.

Mr. SISK. The Chair recognizes the gentleman from Indiana.

Mr. ROUSH. Concerning all of these various amounts, I have wondered, Doctor, how you go about estimating what you are going to need, particularly in a field such as you have on this particular item. It isn't a matter of just drawing a figure out of a hat, is it?

Dr. SILVERSTEIN. No, sir. There is a great deal of experience in this work in the field because, as you know, this practice of initiating preliminary designs and studies has been one which has been followed for years in military services in getting their initial designs started. The costs of these contracts are estimated on the basis of the manpower required to do the job in a reasonable time and quite accurately can be predicted.

Mr. SISK. Does the gentleman have any further questions?

Mr. ROUSH. Not at this time.

Mr. SISK. Does consultant have any questions?

Mr. WILCOVE. No.

Mr. SISK. In view of the fact our colleague from California, Mr. McDonough, has not arrived, the Chair suggests we pass over action on this and take up after he does arrive.

So, Dr. Silverstein, we will move on that to the second item regarding booster recovery systems. There again your request is for an equal amount of $1,500,000. You also had half a million dollars in 1959. Will you make a comment as to what has been committed on that, and also your justification for the additional request?

Dr. SILVERSTEIN. Yes, sir. We in this item are initiating design of systems for recovering of the principal boosters used in our space systems. These boosters are expensive items, as you well know.

They involve the use of engines that are quite expensive and represent a great deal of engineering effort and manpower as well as production manpower.

If a technique can be developed by which, when these things are fired and after they have been fired, that they can be recovered and reused, then major savings could be accomplished.

As yet, no one has developed this technique. We propose to sponsor research and development that will lead to methods for recovery. It will be expected that both initial designs, followed by tests, will be required and the funds we are asking for cover that work.

Again this has been one of the programs that we have held off as yet initiating, principally to determine what vehicle we would wish to spend our efforts in. As our program for vehicles is developed, using principally the Atlas as the first stage, this studies now will be directed toward recovery of the Atlas as a first effort.

Mr. SISK. To what extent are you proposing in your initial studies to attempt to recover the vehicle.

Dr. SILVERSTEIN. The first stage is the most important one to recover.

Mr. SISK. That is why you are going to concentrate on the first stage?

Dr. SILVERSTEIN. Yes, sir, the point being, as you know, the first stages of rockets are the biggest, and the most expensive. The biggest gains are to be made by recovering these stages.

Mr. SISK. Have you actually done any experimental work at all in this, or has it been primarily just studies so far?

Dr. SILVERSTEIN. So far it has been study and analysis. We have come up with several possible ways of receiving the boosters. One obvious method, of course, is the use of parachutes and inflatable objects to be inflated at landing. These are preliminary studies and we need to carry them one step further and find out, after these systems are developed, whether in fact the overall system concept will lead to these costs.

Mr. SISK. What actually is the weight of an Atlas first stage once the fuel is all discharged? What is the average recovery weight you are seeking there?

Dr. SILVERSTEIN. I had better not give you an exact figure, but approximately the figure will be around 20,000 pounds.

Mr. SISK. The exact figure is classified information? Is that right?

Dr. SILVERSTEIN. Yes.

Mr. SISK. The gentleman from Indiana.

Mr. ROUSH. What happens to these first stages right now? Do they fall into the sea or do they go high enough so that when they fall back they disintegrate?

Dr. SILVERSTEIN. They currently fall into the sea, and in all probability on landing they will be pretty well beat up.

Mr. ROUSH. The other stages: Do they also fall into the sea?

Dr. SILVERSTEIN. Yes, sir, all except the last stage which goes into orbit with the object it is carrying into orbit.

Mr. ROUSH. In this program, will it be a matter of also looking into the material which makes up, say, the Atlas first stage in order to increase its recoverability? Or is it just a matter of developing a method or system of recovery?

Dr. SILVERSTEIN. Largely a technique for recovery. You can see here, with a very difficult problem, these things were fired, say, a hundred miles into the air and land over several hundred miles away, depending on the kind of an orbit you are entering into. So we have not only the technique but also the actual recovery method and the cost of that which has to be evaluated.

It may turn out that recovery costs, the use of boats or airplanes to recover, might be more expensive than the object we are recovering is worth. This needs to be studied.

Mr. ROUSH. The expenditures then for the most part will be a matter of spending money on manpower?

Dr. SILVERSTEIN. Largely, manpower by contract. There will be some tests involved here. We have to find out just exactly how the mechanism is going to work.

Mr. SISK. Our consultant has a question.

Mr. WILCOVE. I presume it will be pretty difficult to estimate how much this program will cost in the end?

Dr. SILVERSTEIN. After we make this study, we would know very much better as to what the system would cost. It will depend a great deal on what we learn in the study as to what the final cost will be.

Mr. WILCOVE. Are your people confident they can work out a recovery system?

Dr. SILVERSTEIN. I would say I am not confident now. I am open-minded. I feel that we have to do this work in order to know the answer.

As usual in the field of this type, you will find exponents of both sides. I think the truth doesn't exist yet. I think there is enthusiasm, but no truth, and I think we need to get at the truth.

Mr. WILCOVE. What would you say would be the cost of the first stage of the Atlas?

Dr. SILVERSTEIN. Again I would prefer not to present this in this session.

Mr. SISK. As I understand, the cost of the initial stage is classified information?

Dr. SILVERSTEIN. I don't know whether it is or not, but I can give it to you, I think, approximately.

Mr. SISK. In other words, of course, the value of the first stage concerning which our consultant is seeking information——

Dr. SILVERSTEIN. I would say several million dollars is an answer I can give.

Mr. WILCOVE. That will give us an approximation of the savings, of course.

Dr. SILVERSTEIN. Some of the later vehicles we want to save, such as the more advanced boosters beyond that which we will develop a technique in our early experiments, will be much more expensive than that. It will be up in the order of $10 million or $15 million.

Mr. WILCOVE. Of course these various stages could be rebuilt and used again?

Dr. SILVERSTEIN. That is our intent.

Mr. WILCOVE. So the savings would be rather substantial.

Dr. SILVERSTEIN. Oh, yes.

Mr. SISK. If there are no further questions, we will pass on then to the next item which is orbiting space laboratories for which you

are requesting $2 million in 1960. As I understand, there has been no money heretofore requested for this particular program, is that correct? This is a completely brandnew program?

Dr. SILVERSTEIN. That is correct. I think you may have recalled Mr. Wyatt's presentation the other day in which he showed a picture of an orbiting space laboratory. This program definitely is aimed at the future. It is aimed at providing a background for the thing we see will be coming along as soon as our booster capability is built up to the level at which we can actually put into orbit these laboratories. In the meantime there is a great deal of technology that needs to be established. For example, we have problems here of the types of instrumentation required for a laboratory in which people will continue to live for rather substantial periods of time.

We have instrumentation on the stabilization, the adaption of powerplants, the adaptation of these auxiliary power systems that we discussed earlier. All of this is a design job, and the way in which these systems will actually be developed will depend a great deal on the steps we take now leading toward an understanding of the kinds of things we will need in these laboratories of the future. The kind of work we need to do in order to lay the firm background for the work ahead.

Mr. SISK. That, of course, brings up the interesting question on this particular project. When we start talking about laboratories in space, you have a most intriguing and fascinating subject. But I am curious as to your justification for money at this moment in this particular program, since we must apparently first develop auxiliary power systems and far higher capabilities of thrust. We must develop the technique of, let's say, assembling this project in space piece by piece.

I do think those of us who are going to have to justify this program on the floor of the House need as much backup information as we can get. As I say, it is an intriguing thing, but I am wondering to what extent appropriating money for this specific item, separate and apart from all the other components, could be justified at the present time.

Dr. SILVERSTEIN. I think we have to say this, initially the laboratories we put up will be not assembled in space, but will be put into space in one piece. As we get moving along in the program later, we will assemble laboratories in space.

I would visualize the initial effort in this direction to be laboratories that will be boosted up with the vehicles which we are describing in our program here. One of the most important things, I think, that we must understand in this sort of an effort is the need for going ahead initially with this approach that we are taking of studying things like these laboratories ahead of time so that when we get to the real need for them that the basic research and development required for doing them is well established.

In this way we save money and very substantial sums of money. One of the major weaknesses, I think, in many of our programs in the past has been that we have moved into final development of an article without having laid down the appropriate base.

These sums of money in this area that we are asking for, I think, are the best investments that we can make currently. Without them,

we are going to reach the point where it is going to be quite obvious that we should have carried on this work and had failed to. Then you run into the concept of the crash program which we discussed, I think, last week. In this case there is the immediate urge and the necessity for doing something in a hurry, and all you have are planning pieces of paper in front of you to start with.

Our experience tells us and the experience of everyone in this business has taught them that you must lay down the initial groundwork.

Mr. SISK. I am completely sympathetic to your suggestion, Dr. Silverstein. The only question that occurred to me that might arise, as I have already suggested, is, let's say, how far ahead of ourselves are we getting in this. I am fully sympathetic with the idea that we must do a lot of basic research, have the answers as near as is possible, and then be prepared to really utilize some of these things when the time does come.

Let me ask you this for the record, if we can spell it out in a little more detail: What will be the one, two, three principal things to be studied in this research project separate from the auxiliary power units which we have discussed; the various types of space engines that we might use in space, separate from the thrust that would be required, and from the shielding which might be necessary. As I understand, there are other projects dealing with a study in the type of shielding as far as radiation would be concerned, and so on?

Can you for the record enumerate the specific studies that would be involved in this?

Dr. SILVERSTEIN. Yes, sir. Along the lines of your discussion you have enumerated for me many items that will need to be integrated into the package.

Mr. SISK. That is correct, I am sure.

Dr. SILVERSTEIN. Our studies will be aimed toward the method of integrating these various objects into the structural package which will represent the final capsule. Specifically in a one, two, three order, our first approach to this will be to use a capsule along the lines of the Mercury capsule initially as a test article, and the timing of this is then timed to some point in the Mercury project wherein a capsule can be made available. This will be the first phase. We will be worried to hear about the problems of the types of stabilization that we will use for these capsules for long-time and continued operation in space.

We will be worrying here about the adaptation of the life science equipment of these capsules, for again the longer time period they will operate in space.

On the other hand, we will again be going ahead with our studies for the next phase beyond this capsule. Studying capsules that will be larger, studying capsules that will take our more advanced boosters to put them into orbit.

Have I been sufficiently detailed?

Mr. SISK. I think so, Dr. Silverstein. Much of the information which you will gain from the Mercury project will certainly be relevant so far as this program is concerned. It will undoubtedly pertain to all aspects of it, including communications and the other things that will be needed.

The gentleman from Indiana?

Mr. ROUSH. I have no questions.

Mr. SISK. Does consultant have questions?

Mr. WILCOVE. Doctor, the $2 million you have for 1960 is just a small downpayment, then, on this project?

Dr. SILVERSTEIN. The initial payment. I think again at an early stage when we are doing the work to particularly answer the questions you are asking, coming out of this work, I would say would be an answer to the questions you are asking—how much will it cost us to do these things in the future?

Until we make these studies, we really can't answer that question very adequately.

Mr. WILCOVE. Of course, it is a question that is bound to arise when you start talking about the ultimate cost.

Dr. SILVERSTEIN. It is, and I think this is the kind of a question that is pertinent. I think for that question to be answered intelligently you have to do work in the field. What we are really asking for here is the money to get this thing started so we can intelligently assess the cost of this program for the future and the cost of our whole space program for the future.

This is the type of work that we need to reach that point of view.

Mr. WILCOVE. Are you saying, then, that you can give no estimate at all as to the ultimate cost of this project?

Dr. SILVERSTEIN. I think I would be wrong to say I could give no estimate at all.

Mr. WILCOVE. Did you have an estimate?

Dr. SILVERSTEIN. I can probably make up some sort of an estimate. I believe myself that we are after really engineering estimates rather than what I call crude guesses. Rather than deceive anyone with crude guesses, I would much prefer to be able to give estimates. It is a desirable thing to do, I think.

Mr. WILCOVE. It makes it rather difficult when an agency starts a program and is not able to give any idea what the ultimate cost is.

Dr. SILVERSTEIN. I think we start most of our programs, don't we, without knowing the ultimate cost? This space vehicle here will in fact be one of the principal items in the whole space program of the future. We will expect to have space platforms. What the ultimate cost will be will depend on indeed how the whole space field develops with time.

This is only one aspect, an initial development aspect, of this field. I am sure I cannot, nor do I think almost anyone else could predict the ultimate cost of this space program.

Mr. WILCOVE. I realize how difficult it is to determine exact costs or even a rough approximation. But if we start a program and are unable to give an estimate of how much it will cost, we are really giving you a blank check here—assuming that we carried the program through to its ultimate end.

Dr. SILVERSTEIN. I think the committee will have the opportunity after this study is finished to learn from us what the cost will be in the future, and at that time we will be in a better position, I think, to assess the situation from a realistic point of view.

Mr. SISK. If the staff would yield right at this point, actually this original study which you propose to make here for the $2 million. Again I assume that will be contracted out?

Dr. SILVERSTEIN. Yes, sir.

Mr. SISK. Instead of inhouse?

Dr. SILVERSTEIN. It is contracted.

Mr. SISK. At the conclusion of this study would you anticipate, Dr. Silverstein, that you then would be in a position to come before our committee and give us, let's say, some fairly good figures as to the ultimate cost of developing this? I am not trying to pin you down because I probably will not attempt a year from now to say "you said a certain thing," but at the same time, do you anticipate a year from now you will be in far better position to say this program will cost $100,000 or it will cost $1 billion or some such figure? Is that your intent so far as this original study is concerned?

That is a part of it, I mean?

Dr. SILVERSTEIN. Yes, sir; very accurately stated. I have been making this point—these studies are the groundwork studies that will lead us to an understanding of the cost.

Mr. SISK. I am fully sympathetic with what our consultant is attempting to bring out here. We have discussed this matter before. This is one of the problems that we are going to be confronted with on the House floor, namely the question "What are you committing us to? To what extent is the American taxpayer being committed when we start a new program?"

Of course, I can understand, I think, and I am sure we all can, there are so many things we do not know that it is impossible, I realize, for you to say today that it is going to cost a figure, even an estimated figure, to get one of these space vehicles, one of these particular types of laboratories, in space.

But at the same time I think we have got to be able to give the House as much information as possible. I would say with reference to this one, primarily, all we are doing is attempting to make a study to determine, first, is it feasible engineeringly and scientifically, and then, of course, what is the economic feasibility of it.

Dr. SILVERSTEIN. Yes, sir. This is the interesting point, and you have brought it out quite well, that this program doesn't commit you to anything. It commits you only to trying to understand what the cost will be because it is not in truth a development program. The place you have to be careful is in starting a development program that does commit you to large sums of money. But this program is not a committing type program. It is a study type program.

So it brings us to the point that when we do come before you to ask to carry this into development, we can intelligently tell you what the program will cost rather than to bring you a blank piece of paper.

Mr. SISK. Actually, in the items we have gone over so far, so far as a real commitment is involved, the one thing we are really basically committed on, of course, is this single-barrel engine. That we know we are committed to a pretty substantial sum of money. The balance of these, practically all, are having to do with basic studies then.

Is that right?

Dr. SILVERSTEIN. Thus far.

Mr. SISK. Go ahead, Mr. Wilcove.

Mr. WILCOVE. That is all, Mr. Chairman.

Mr. SISK. The gentleman from Indiana?

Mr. ROUSH. I have nothing further.

Mr. SISK. All right, we will pass on to the next item which comes under a new heading, "Supporting activities." We have an item of "Tracking and data acquisition" for $11,500,000. You were given $3,300,000 in fiscal 1959.

Would you comment as to what portion of that, if any, has been used and what portions are committed or obligated, where there is going to be any carryover to be used, and so forth?

Dr. SILVERSTEIN. Sir, these funds that have been made available in 1959 are largely committed at the present time. There will be almost no carryover of these funds. The fiscal 1960 funds that we have shown here are for the operation of our tracking and data acquisition facilities, and to develop improved tracking and data acquisition systems at some of our existing facilities.

Since the largest item is involved in the operation and technical service for our existing facilities, let me briefly run down the types of expenditures in this area. I think you recall again that Mr. Buckley showed you in his initial presentation to the whole committee the types of facilities that we are operating. These include the net of optical stations; the Minitrack net which he showed you the locations of, I think, on a map; the beginnings of our deep space net, which are now going into operation.

It is for the purpose of maintenance and operation of these stations for use with the satellite vehicles in the deep space probes that will be fired in the current and coming years that we will use these funds.

There is $7.5 million of this $11.5 million which is directly aimed toward the support of these facilities.

Mr. SISK. In the course of your discussion will you mention some costs on these Minitrack stations? Just how expensive are these Minitrack stations and their equipment?

Dr. SILVERSTEIN. Yes, sir. The Minitrack stations cost about approximately $1 million to put in. This includes all the radio equipment, the ground antennas, the small support equipment that is required at each of the different stations to maintain the staff and to house the instrumentation.

Mr. SISK. Those stations cost approximately $1 million apiece?

Dr. SILVERSTEIN. Approximately.

Mr. SISK. How many of those do we have now? Can you give that information?

Dr. SILVERSTEIN. Yes. There are currently 10 of these stations.

Mr. SISK. We have 10 Minitrack stations?

Dr. SILVERSTEIN. Yes, sir.

Mr. SISK. Some of those are in this country and some are outside. Is that right?

Dr. SILVERSTEIN. Yes, sir. We are currently augmenting this track by four additional stations to take care of our high-angle firings and our polar firings. The current stations, as was pointed out in the discussion by Mr. Buckley, are aimed largely to acquire information from satellites on an east-west track such as have been fired from Cape Canaveral. In our late firings we will use high-angle firings out of Canaveral and also polar firings, which mean that the stations now which are currently located almost on a meridian will be spread out laterally so that we can catch these firings as they go around.

To support the Minitrack stations, we are asking for $4.42 million. To support the optical net we are asking for $2.4 million. Incidentally, both of these numbers are fairly well established because we have contracts for the operation of these stations currently and these contracts are being extended.

We are using the Joddrell Bank Station in England. As you know, this is the large 250-foot dish. We expect to spend a quarter of a million dollars in support of our activities in the coming year for this dish.

Then for particular flights we establish portable stations at different places and ask support of other groups. We have an item of $4.3 million for this, adding up to the $7.5 million for the operation of the technical service.

Mr. SISK. With whom are most of the contracts? Can you give us some information on the concerns with which you have contracted? Who is doing most of that work?

Dr. SILVERSTEIN. Yes, sir. For example, some of our stations are under contract to the Bendix Co.

Mr. SISK. The Bendix Corp.?

Dr. SILVERSTEIN. The Bendix Corp. Others are with universities in South America. We attempt, where possible, to contract in, for example, a foreign country with a technical group there who are qualified to do the work, providing only—in that case—one of our representatives is at the station to serve as a point of contact and to provide us with a general command of the situation if we need that.

Mr. SISK. Under this item here, "Prototypes and operational hardware," you have "Telemetering receivers, tracking antennas, transmitters-receivers, read-out devices, and data recorders"—all of new design, $1.5 million.

Are most of these purchases being made from domestic companies for all of the various stations, or is some of this hardware being acquired from foreign companies? What is the situation on that?

Dr. SILVERSTEIN. The hardware will largely be from domestic industry. Some of these funds will be required for work at the Jet Propulsion Laboratory in their research on advanced components.

I might point out in this connection there is a continually developing technology in this area that is enabling us to look very much deeper into space using new amplifiers and new antenna techniques. We are making very rapid progress here.

Mr. SISK. These optical stations here, the Smithsonian optical stations: To what extent is any money being expended in what you might call real studies or basic research in this field? Or is this primarily all for existing equipment and money for their maintenance and operation?

Dr. SILVERSTEIN. Largely the operation of existing equipment which has turned out to be quite satisfactory. There are minor changes that are made in the equipment as we move along in the program, but I think we can say that they are largely in support of the equipment that exists.

There are 12 stations using the optical cameras.

Mr. SISK. There are 12?

Dr. SILVERSTEIN. Twelve.

Mr. SISK. Are those all operated by the Smithsonian?

Dr. SILVERSTEIN. Yes, sir.

Mr. SISK. All 12?

Dr. SILVERSTEIN. All 12.

Mr. SISK. What is the general location of those?

Dr. SILVERSTEIN. We have a chart that shows all of those locations. Can you pull it out?

Mr. ROUSH. This is not the Minitrack?

Dr. SILVERSTEIN. No. These are optical cameras. You might pull out the picture of the optical camera, too.

Mr. SISK. I have been interested in this optical situation. Of course, as you know, we had quite a little discussion over what some people felt was a lack of cooperation on the Discoverer shot. As I understand, it partially started because the Smithsonian Institution indicated, I believe, they were not properly alerted to this fact and they felt they could have picked up some of these.

Whether that be true or not, I am not trying to enter into that argument. I am just curious to what extent we have these stations scattered and to what extent they can contribute to the tracking of these.

Dr. SILVERSTEIN. I am very sorry, we will bring this chart over for you. We don't have it with us.

Mr. SISK. Let me ask you just for general information, Dr. Silverstein. Are they pretty well scattered over the world, or are they concentrated in a few given spots?

Dr. SILVERSTEIN. They are fairly well scattered. They are scattered quite widely.

Mr. SISK. What is the most northern site, or are you in a position to say—for example, in the polar regions? What do we have in the way of optical observation in the polar regions?

Dr. SILVERSTEIN. I think we have none of this type of cameras in the polar regions that are in the Smithsonian net. I should have qualified my statement by saying that they are fairly widely scattered in longitude, but are not located too far north and south. This is associated with the fact they were established during IGY and were set up specifically to observe the satellite firings of IGY, which were confined to this plus or minus 33 degree north-south orbit.

So they are not too northerly located.

(The information requested is as follows:)

The 12 camera stations are located at Woomera, Australia; Organ, N. Mex.; Olifantsfontein, South Africa; Cadiz, Spain; Tokyo, Japan; Naini Tal, India; Arequipa, Peru; Shiraz, Iran; Curacao, Netherlands West Indies; Hobe Sound, Fla.; Villa Dolores, Argentina; and Haleakala, Maui, Hawaii.

Mr. SISK. The gentleman from Indiana?

Mr. ROUSH. On the amount that you are asking for the support of the Minitrack system or stations, does that include any new stations other than these four that you are currently—I understand you have 10 and are currently installing 4 more. How many more are we going to have?

Dr. SILVERSTEIN. We have none contemplated currently.

Mr. ROUSH. Then the amount you are asking for is merely in support of the operation of those?

Dr. SILVERSTEIN. Yes, sir.

Mr. ROUSH. It takes an awful lot of money to operate one of those, doesn't it, or maintain it? You had $4 million plus, I believe you stated.

Dr. SILVERSTEIN. $4.42 million.

Mr. ROUSH. To support 14 stations. What did you mean by the support of the stations?

Dr. SILVERSTEIN. There is manpower at these stations. There is a staff of some 14 or 15 people at each of these stations, plus the logistics support for the station. They are worldwide and these stations have to be supported on a year-round basis. It becomes quite an expensive operation.

Mr. ROUSH. I have nothing further, Mr. Chairman.

Mr. SISK. Consultant?

Mr. WILCOVE. I was under the impression that our station at the South Pole was carrying out some observations of the Discoverer satellites. Is that part of your network?

Dr. SILVERSTEIN. That is not part of the Smithsonian net.

Mr. WILCOVE. Is there any connection between the South Pole station and the NASA?

Dr. SILVERSTEIN. That probably would be part of the military net because this is their program.

Mr. WILCOVE. I think it was part of the IGY setup.

Dr. SILVERSTEIN. I perhaps should study this and then give you an answer on that.

Mr. WILCOVE. Will you supply that for the record?

Dr. SILVERSTEIN. Yes, I will.

(The information referred to follows:)

The observations at the South Pole were not made by the IGY working net. As far as we know, a satellite tracking station has not been established at the South Pole. National Aeronautics and Space Administration, in any event, does not have one at this point.

Through coordination of information with the Department of Defense we know that a Navy task force supporting the U.S. IGY group in Antarctica, was aole to make visual sightings of the Discoverer satellite.

Mr. SISK. As I understand, then, to sum up, the $11,500,000 is a pretty concrete amount that will go into needed hardware and maintenance of these stations and the hardware concerned for fiscal 1960.

Dr. SILVERSTEIN. Yes, sir. These numbers are quite firm. They are based on contractual arrangements.

Mr. WILCOVE. Mr. Chairman?

Mr. SISK. Yes.

Mr. WILCOVE. With respect to Joddrell Bank, some of the members and staff of our predecessor committee visited Joddrell Bank. At that time, the director, Professor Lovell, was quite concerned about obtaining sufficient finances to operate this important installation.

I was wondering whether you contemplate any further contracts with Joddrell Bank other than this quarter-million-dollar contract, something more substantial perhaps?

Dr. SILVERSTEIN. Nothing currently. This will support the effort for which we will use the telescope.

Mr. WILCOVE. Looking forward to the future, do you have any other plans with regard to Joddrell Bank?

Dr. SILVERSTEIN. Not currently. This is an English installation, of course, and it has been very useful in our programs. We are interested in continuing to use it. We have discussed this problem with Lovell. This is somewhat the result of our discussions.

Mr. SISK. With reference to this Joddrell Bank deal and our cooperation with England, of course—in fact, this is a wholly owned English operation—to what extent are we getting or proposing to cooperate with other countries which may be interested in this space program? For example, in Australia, we have Minitrack stations now; do we not?

Dr. SILVERSTEIN. Yes, sir.

Mr. SISK. To what extent, if any, are these other countries cooperating in the financing of this? Or is this situation, as far as NASA is concerned, exclusively American and, therefore, we do not seek any cooperative agreements?

Will you comment on that?

Dr. SILVERSTEIN. We expect to use the scientific personnel in these countries. For example, in Australia we are currently using scientific people. In Australia, as you know, they have been one of the most progressive countries in radio astronomy and have some of the best radio astronomers in the world in Australia. They are now putting up a larger dish, some 200 feet in diameter, in Australia, which, after it is completed, may be useful in our program.

We are discussing this with them at present. Our cooperation with these scientific people throughout the world is on a continuing basis. I spent Saturday with a representative from Australia in this area.

Mr. SISK. I would like to have the record show that our colleague from California, Mr. McDonough, is now with us.

Actually the reason I asked that question, of course, is the fact that we do have these stations, I am sure, scattered about over the world. I was curious to what extent we do have any type of operation of this kind in southeastern Asia or the Middle East. Are we getting any cooperation in any of these programs throughout that area, and to what extent is that area valuable in tracking?

I am thinking, frankly, of the periphery of the Communist empire and what possible effects it might have on information that we might seek or need with reference to our experiments with satellites in all phases, let's say, of the program, and to what extent, if any, you may anticipate or already have had problems on getting locations or getting the cooperation of these people.

Do you have any comment on that, Dr. Silverstein?

Dr. SILVERSTEIN. Nothing specific. We have had no difficulties as yet in getting cooperation in these areas. We have tried to locate our stations, of course, at fairly stable points politically so as to assure us continued operation and have not necessarily moved into areas where there was some possibility that we couldn't continue our effort over a long period of time with an agreement that would be binding.

This is a practical point that I think has made fairly good sense.

Mr. SISK. The gentleman from California.

Mr. MCDONOUGH. In manning these stations—take one in a remote area—how large a personnel do you have? Is it all American personnel or does it include natives of the area in which it happens to be located?

Dr. SILVERSTEIN. Where possible—for example, in our South American stations and Australian stations—we have attempted to use the talents of local people, using only supervisory talent, if possible; and in some cases using largely the local people for operation.

Mr. McDONOUGH. How large a staff would you have on a remote station, one that isn't used as much as some other stations?

Dr. SILVERSTEIN. A staff of about 15 to operate the station. They have to be operated on a round-the-clock basis during firings.

Mr. McDONOUGH. Are they all under the security program? Are they required to be, even the foreign personnel?

Dr. SILVERSTEIN. I think that I will have to check and see.

Mr. GLEASON. Yes, they are.

Mr. McDONOUGH. In other words, they are thoroughly tested so we know they are loyal and reporting exactly what occurs? They can't report otherwise because the mechanism reports the situation, doesn't it?

Dr. SILVERSTEIN. Yes, sir. There is very little that any one individual could take from the data because the data is on tape basically and is transferred that way. It is not interpreted until it reaches this country.

Mr. McDONOUGH. What is the approximate cost of an installation for tracking?

Dr. SILVERSTEIN. A Minitrack station will cost in the order of $1 million. Some of our deep space antennas, the large antennas, are much more expensive than this. They are in the order of $2.5 million to $3 million per installation.

Mr. McDONOUGH. We have how many tracking stations?

Dr. SILVERSTEIN. We have eight Minitrack stations now in operation. We are adding four. We are currently combining two of our stations into one. The Cuban station and one of our other stations is being combined into a single station. So we did have one more. Now there will be eight.

Mr. McDONOUGH. The funds for the additional two stations are in this appropriation?

Dr. SILVERSTEIN. The C and E funds are shown in the C and E budget. The funds for operation are shown in this budget.

Mr. McDONOUGH. Nothing further, Mr. Chairman.

Mr. SISK. By the way, you spoke about those C and E (construction and equipment) funds. What is the total of those?

Dr. SILVERSTEIN. The total of the C and E are shown in "Construction." They add to a total, in 1960, of $10 million. They are shown in the construction budget. I can refer you to a page here.

Mr. SISK. We don't necessarily need the breakdown. That is being handled by another subcommittee. But in order to get a round total of what is involved in this overall deal, there is $10 million in facilities, actual facilities?

Dr. SILVERSTEIN. For 1960.

Mr. SISK. So the whole program on this is about $21,500,000, if we add the two figures together for tracking and data acquisition—$21,500,000?

Dr. SILVERSTEIN. Yes, sir.

Mr. SISK. For 1960. We had $3.3 million on this figure. What did we have in the 1959 figure on the facilities?

Dr. SILVERSTEIN. In facilities, we have an item that was authorized for the supplemental appropriation in 1959 in the amount of $12.5 million.

Mr. SISK. $12.5 million of that supplemental was for these purposes?

Dr. SILVERSTEIN. Yes, sir.

Mr. SISK. I recall now the discussion on that at the time. In other words, we are getting quite a bit of money into this tracking and acquisition data. I certainly can understand that it is needed. There is no point in putting up satellites if we can't get the information back. But it does become a rather expensive proposition, then, because when we add all these figures together, we can get up to $40 million or $50 million pretty quick on that particular program.

Dr. SILVERSTEIN. Yes, this is an expensive part of the program, but an absolutely essential one.

Mr. SISK. Any further questions dealing with this tracking and acquisition program?

Mr. MCDONOUGH. When a satellite is in orbit and you track it through your Minitrack stations, how rapidly and to what point do you report all this information so there is a constant coverage of the orbiting of the satellite?

Where do they report to?

Dr. SILVERSTEIN. Currently they report to the control center at the Naval Research Laboratory. This center will now be at our Beltsville Laboratory, which has been described in this budget.

Mr. MCDONOUGH. They reported immediately?

Dr. SILVERSTEIN. They reported almost immediately through TWIX—that is, through the worldwide communication system that has been established.

Mr. SISK. Did you have a question, Mr. Wilcove?

Mr. WILCOVE. Doctor, has any arrangement been made with the Russians as far as tracking is concerned?

Dr. SILVERSTEIN. Not to my knowledge.

Mr. WILCOVE. You have no arrangement at all?

Dr. SILVERSTEIN. No, sir.

Mr. WILCOVE. Has any effort been made to set up some kind of an arrangement?

Dr. SILVERSTEIN. We have made none. I think you recognize the fact that our whole relationships with the Russians in this area are now a matter of concern at the United Nations, and that there are to be discussions later this year with relation to the position of the United States and Russia in the space field.

There is an action that is outside of this area under the jurisdiction of the international unions, IGSU, which has established this committee. This commitee has representation from Russia and other nations outside of the NATO setup. They have not as yet discussed the tracking problem.

Mr. WILCOVE. My thought was that Russia proper and Siberia cover one-sixth of the earth. The Discoverer satellite, for example, will pass over Russia. That leaves quite a gap in the network, doesn't it? Discoverer satellites don't come under your jurisdiction, but at the same time one-sixth of the globe leaves quite a gap if you have no reporting system there.

Dr. SILVERSTEIN. I think there are stations that will cover the whole globe for our deep space net, because we are spacing them around the

earth 120 degrees apart so we won't have a break in our net for the deep space probes.

Mr. WILCOVE. But do you have a break in the network for your orbiting satellites?

Dr. SILVERSTEIN. In the orbiting satellites, of course we have fairly continuous recording, and we can read out, you see, at any one of the stations that we choose.

Mr. WILCOVE. I am somewhat surprised that NASA has made no effort to at least contact the Russians. I understand from some of our scientists they were rather surprised at some of the information they received during the IGY from the Russian scientists.

Dr. SILVERSTEIN. There has been an exchange of information through the IGY and information has been received from them on technical subjects.

Mr. WILCOVE. It might be worthwhile for the NASA to contact them, to see if some arrangement can be set up, through the State Department, I assume.

Dr. SILVERSTEIN. Yes; I think the State Department would be the appropriate channel.

Mr. SISK. If the consultant will yield: With reference to the communications satellites, which, of course, are a very important phase of this overall program, to what extent has consideration been given, in the setting up and development of these communications satellites, to agreements with the so-called Communist bloc. Has there been any, or do we propose in the communications satellite field that, when we are ready to move, so far as setting up our three or four or as many satellites as we determine are necessary to carry out this world-wide communications network, to what extent do we propose to enter into agreements or anticipate any agreements with the Communist bloc?

Dr. SILVERSTEIN. I don't really think I am qualified to develop this subject, Mr. Chairman. I think here we are discussing something that involves a policy at probably the highest levels of the State Department in our administration. I am really not qualified to answer your question.

Mr. SISK. Are there any further questions?

If not, what is the pleasure of the committee, then, in view of the fact that Mr. McDonough is here now, with reference to action on this supporting activity toward recommending $11,500,000 asked for in that figure?

Mr. MCDONOUGH. I move it be approved.

Mr. SISK. The gentleman moves it be approved. Without objection, the subcommittee approves for recommendation to the full committee the item of $11,500,000 for supporting activities under the subheading "Supporting activities, tracking and data acquisition."

Mr. MCDONOUGH. Mr. Chairman, if you will go back to the space system technology——

Mr. SISK. I will be very glad to. The gentleman from California, any questions he may have there on those three items, just proceed.

Mr. MCDONOUGH. Will you review generally the advanced vehicle systems and the booster recovery systems, those two items?

Dr. SILVERSTEIN. Yes, sir. The advanced vehicle systems I discussed earlier, and pointed out that as we go to new vehicles such

as the Nova vehicle, there is a need, and a continuing need, to do the basic studies on the structure and the arrangement of these vehicles so that when we reach the point at which we actually have to lay down a design, we have covered the basic research and the basic studies that are needed to do it.

This avoids the crash program concept. What we propose to do both in the advance vehicle systems and our recovery systems is to do study work and preliminary technical work which will lay down this background.

Mr. McDonough. That is for those two items, a total of $3 million—advanced vehicle systems and booster recovery systems.

On the orbiting space laboratories, isn't that program quite advanced? What are you going to do on that?

Dr. Silverstein. Here again we are dealing with an advanced subject, but we are dealing with it in its early phases. As I described earlier for the members, here again we need to start with what we have, and our initial work in this area will be with the Mercury capsule, and work out the system development, the application of all components that are being developed in separate parts of our program, the integrating of these and their mission into the laboratory.

By going at this work properly, we can, I think, bring ourselves to the point where we can assess for ourselves and assess for you the continuing developments in this area.

The question was asked here earlier as to what the final cost of this might be. I point out that this program is aimed very specifically at finding out numbers such as this as a result of engineering studies. It is a fair question to ask how, as we move along in this space field, the costs will mount in the future. But to do this intelligently requires study. These are going to be contracts which we will let to qualified people who are working in this area to do the structural work, to do the analysis and the component integration into these vehicles so that we can evaluate their future costs as a result of the work.

Mr. McDonough. I heard a radio broadcast last night that said we can expect to land a man on the moon and return him to earth within 8 years, at a cost of $20 billion. That was an estimated report to the public.

Dr. Silverstein. This is one of the reasons I am very cautious about giving these costs. There are so many people who are sounding off in the same fashion, who have no more basis for the numbers than if they were the man in the moon, that I don't like to join this tribe. I would much prefer to do the work required to determine the cost and then tell you what they were.

Mr. Sisk. If my colleague will yield, apparently the fellow who came up with those figures made me look like a piker the other day when I was trying to get some figures regarding the cost of landing a man on the moon.

Dr. Silverstein. I don't know these costs.

Mr. McDonough. In other words, these figures will lead you into estimating what the actual cost will be.

Dr. Silverstein. Very correct.

Mr. McDonough. Do you have any idea that with a year's opportunity to study the matter you will have something more or less definite along those lines in a year?

Dr. SILVERSTEIN. Much more definite. This is a sound process by which you arrive at costs, by making adequate studies. Other than that they become mere guesses, which float around and which have no meaning.

Mr. MCDONOUGH. Aren't advanced vehicle systems and space engines pretty much along the same lines of study?

Dr. SILVERSTEIN. Except that they are associated with components that will be a part of these advanced systems. This development is essentially more a vehicular type of thing where all of these are combined together. If you will recall you saw the other day a picture of what might be a space platform, presented by Mr. Wyatt. This currently is an artist's picture. We must get down much closer to the engineering.

These are big problems. They are not small problems. They are not problems that someone dashes off in the back of his notebook. They require very, very detailed studies.

Mr. MCDONOUGH. Is there any development along either of these three lines under space system technology by private industry?

Dr. SILVERSTEIN. These studies will all be by contract.

Mr. MCDONOUGH. Outside of contracting with the Federal Government, is there any development by private industry?

Dr. SILVERSTEIN. I think so. It is the practice of aggressive organizations to maintain a certain part of their staff doing advanced thinking. Those who fail to do that generally fail to stay in business. I think without question there must be within industry studies of this type going on.

Mr. MCDONOUGH. Take the entire program here of research and development under your direction, estimated at some $333 million. Do you believe that there is half that amount being done by private industry for its own information?

Dr. SILVERSTEIN. I don't believe that. It couldn't be. The studies they make are generally studies involving a few people in their advanced design areas, and amount to a few million dollars in total.

Mr. MCDONOUGH. I am guessing—you can correct me if I am wrong—are there studies based on anticipated proposals they may make to you as to the development of the machines——

Dr. SILVERSTEIN. Very much so. It is the business of an aggressive organization to be alert and to anticipate the progress of the work. There are no doubt many studies of this type going on within the advanced design groups of companies.

Mr. MCDONOUGH. In other words, there are no commercial dividends from a business of this kind. They can't produce anything that will return any profit to the corporation?

Dr. SILVERSTEIN. No.

Mr. ROUSH. Mr. Chairman.

Mr. SISK. The gentleman from Indiana.

Mr. ROUSH. Along this line it seemed to me what must happen, when you give a contract for a large project, is that the company which gets the project must in turn go to private industry. They take each small contribution and bring it together and finally come up with the answers to your questions insofar as the large project is concerned.

I was especially impressed with that at the recent World Congress of Flight, where numerous industries displayed their wares. For example, in my district we have Delco Radio. They have one small contribution to make to the total picture, and Allison Co., which makes the motors, and Delco-Remy, which makes batteries.

But it appeared to me that what industry must do with a large contract is to utilize this resourcefulness of private industry in achieving your goal for what you paid for them to do.

Dr. SILVERSTEIN. Exactly. Although I am not current on this as of the moment, I think in our Mercury contract for the man-in-space capsule, which was approximately a $20 million contract, there were over 100 subcontractors in that program involving people of the type you have mentioned who were developing particular radio equipment that goes in it, or particular pieces of hardware that are a part of the contract.

These things have been developed and they are subcontracted and purchased by the principal contractor and put together as a unit.

This is the strength of our American industry.

Mr. ROUSH. I was impressed, Mr. Chairman, by the fact that there must be terrific competition among these people, maybe on one small part, in their attempts to get into this space program.

Mr. MCDONOUGH. The situation, however, is slightly reversed to what it was years ago. For instance, Thomas Edison developed his light theories on his own, and came to the Government with them. The Wright brothers did the same thing with the airplane. The Government didn't initiate the action. The Wrights initiated it and brought it to us.

Even the submarine was developed by private interests and brought to the Government, and was more or less turned down as a visionary idea.

Here we are reversing the situation. The Government itself is initiating the action, trying to assimilate certain things to them.

Dr. SILVERSTEIN. Both of these sorts of things still go on, however. Industry is still creating things out of their own strength which become a part of objects such as our integrated objects, the Mercury capsule or a big engine. It still happens. There is still a wealth of ingenuity. There is a wealth of talent in this whole field, say, of solid-state physics where we are developing new types of miniaturized equipment, transistors and solar cells. Tremendous developments are occurring throughout our industry which is a very healthy sort of a thing.

This provides us with a basis for going ahead.

Mr. MCDONOUGH. Consider the X–15 for instance. Did that initiate with us or did that originate with North American?

Dr. SILVERSTEIN. The X–15 actually got started as a result of a study made by the NACA organization, which was then coordinated with the Air Force and Navy after which a competition was held. So it became an NACA-Air Force-Navy project.

A competition was held which was won by North American, and after which the vehicle was brought to its current stage.

Mr. SISK. Dr. Silverstein, wouldn't you say in drawing analogies, when we have the broad view, of course, of the program on which we have launched ourselves, I think the analogy in this instance would

probably be better compared to Columbus' voyage when he had to be financed by Spain, basically.

Don't misunderstand me, I am not being critical of the position taken by the gentleman from California, because I think private industry is contributing a lot to the multitude of instruments, vehicles, ideas, and so on in the program.

But, in the overall, what we are attempting to do is to reach out into a wholly unknown area and discover something new. When you put it all into a nutshell, it would, let's say, to some extent compare with the great discoveries of the past, where they did require public financing—that is, Government financing—by England, Spain, and the other great powers of that time.

Mr. McDonough. If it gets to such magnitude that private industry can't operate, of course the Government is the only agency that can attempt it. But I am hoping that in our development here that we don't turn it around to the point that everybody comes to the Government for funds to do the job, instead of doing something on their own. It becomes more or less nationalistic then.

Dr. Silverstein. I think there is some of each. That is heartening. I think industry has a great creative talent, and they exercise it.

Some objects of this program, of course, are large and expensive, and we can't expect industry to support them because initially they have no commercial use unless they are supported by Government.

Mr. Sisk. If my colleague will yield, it might be that once we have reached out far enough, have made certain explorations of the planets and have developed space stations, that then these private companies will be interested in these one-man vehicles, or capsules, in order to get up there, you know, as the automobile business grew up.

Mr. McDonough. That grew up strictly out of private industry.

Mr. Sisk. That's right.

Mr. McDonough. The Government has used it to good advantage for defense and for transportation.

The only point I am making is that I don't want the Government to be the one source that private industry comes to or leaves to initiate things. I would like to keep the ingenuity of private industry alive and not create a great agency here that everybody has to come to and say "Well, they will have to do it first, because we won't attempt it." Let's see what they can do.

Mr. Sisk. I might ask my colleague, since we passed over three items under space systems technology, is there any objection if we pass on the recommendation of those three items?

Mr. McDonough. No objections.

Mr. Sisk. Without objection, then, it will be considered to be the recommendation of this subcommittee that the three items involved under the subheading of "Space Systems Technology," having to do with $1,500,000 for advanced vehicle systems, $1,500,000 for booster recovery systems, and $2 million for orbiting space laboratories, be recommended.

Without objection, it is so ordered. So we now move to——

Mr. Wilcove. Mr. Chairman, I wonder if I could ask one more question on the tracking network.

Mr. Sisk. Yes.

Mr. Wilcove. When your tracking network has been completed, what will be the annual maintenance cost, Doctor?

Dr. SILVERSTEIN. May I put that in the record? I don't have that number with me.

Mr. SISK. All right, if you will put that in the record, Doctor, we will appreciate that.

(The information requested is as follows:)

The annual cost of operating the NASA tracking network is estimated at $11,500,000. This estimate covers the operation and maintenance of electronic and optical tracking equipment which is under NASA jurisdiction. Of this estimated figure, the annual maintenance cost is estimated at $800,000.

Mr. MCDONOUGH. For the record let us say that the space system technology studies, as the doctor has outlined to us, are basic studies which will lead to the anticipated cost of these programs on a larger scale. The committee is approving them with the hope that these funds will, by the end of fiscal year 1960, produce a fairly accurate estimated cost so that we are not committing ourselves to the entire program by approving these three items.

Mr. SISK. I appreciate the statement the gentleman made, and I think that is in line with some earlier discussions I have had with Dr. Silverstein, that within the coming year they will be in far better position to give us some specific figures.

Now we come to really the big end of the budget which we are confronted with defending. That has to do with about $100 million broken down into four items. I believe in round figures it is approximately $100 million, or so close to it that it won't make much difference.

That is their vehicle development program. We have four vehicles here: Scout, Delta, Vega, and Centaur.

We will start with the small one and then build up, Doctor. Do you have any comments you wish to make on Scout—I might say that in all probability the committee may be confronted with more questions dealing with these particular features than any other. I realize also, the Chair does, that there are certain classified aspects about some of these programs. But as we discuss these vheicles we would like you to give us every bit of information that you possibly can publicly, because, as I say, there is $100 million involved here and we must be in a position to justify our acts as much as possible.

So as we proceed, I would hope that you give us everything that you possibly can before we must go into executive session.

You may proceed, Dr. Silverstein.

Dr. SILVERSTEIN. Starting with the Scout vehicle, which is the smallest in this group of vehicles which we are initiating development on, we are asking for $2 million in 1960. The Scout vehicle is a vehicle which will be used to replace the current vehicles that are being used to put loads of up to 100 pounds into orbit. The Scout vehicle is being designed so it will put 100 to 150 pounds into a 300-mile orbit, or actually 150 to 200 pounds into a 300-mile orbit, and can place smaller loads into higher orbits.

The philosophy of this Scout vehicle is this, that as we have moved along in our technology we have reached a point where we can put together a group of four solid rockets as we are doing in Scout, using the developed rockets that industry has provided from other programs, and by doing this, we can provide a vehicle at a very much smaller cost than our current small vehicles are actually costing us, and provide a reliability using the solid rockets that we haven't as yet attained in our other vehicles.

It is expected that the Scout vehicle, once we complete development, will cost about $500,000 complete, whereas vehicles that put up comparable loads that we are using currently cost as much as five times that amount. The simplicity of the system reduces greatly the launching cost. We are currently launching at Wallops Island, for example, solid rockets with a very short countdown, just a few minutes countdown, using a very simplified type of launcher, and doing it with great success.

In the presentation we made to the full committee we showed a series of vehicles involving solid rockets that have been developed over the past few years utilizing the principles I have just outlined. It has been quite successful.

There is another feature to this Scout vehicle which I think is very important, and that is it is a type of vehicle that in our international relations, our relations with other countries, it is a vehicle that can be provided to them, if necessary, or which we can fire for them from a base where matters of classification don't enter into the problem.

For example, we can fire these vehicles from our Wallops Island station, where no classified work is in progress, and can invite the foreign experimenters aboard without difficulty as to security matters.

There is every reason, I think, to move ahead with this vehicle and to continue its development. In 1959 we have committed almost the full amount of the $6,048,000 that are shown for it. The vehicle is making good progress, and the additional $2 million we ask for here is to complete the purchase of four additional systems to tie these rockets together and four guidance systems.

The rest of the program has been funded for eight vehicles.

Mr. SISK. I was just thinking as I looked at the figures in the breakdown here that actually this program is pretty well—that is, the R. & D. part of it—is pretty well completed with the exception of your flight evaluation. I notice you are asking for $1 million for flight evaluation, and only some rather small items in the other figures. Is that correct?

Dr. SILVERSTEIN. Yes, sir; the contracts are completely let on this program to various industrial organizations who are providing the equipment.

Mr. MCDONOUGH. You mean the whole $6,048,000——

Dr. SILVERSTEIN. Is basically completed.

Mr. MCDONOUGH. Do you believe with the additional $2 million during the year 1960 you will be able to launch one of these rockets?

Dr. SILVERSTEIN. These are the current estimates, sir.

Mr. MCDONOUGH. When will the present contracts advance to the point where you will be able to put together hardware?

Dr. SILVERSTEIN. We are expecting delivery on some of the big rockets in this program very shortly.

Mr. MCDONOUGH. As I recall, you showed charts showing the Scout development during the hearings.

Dr. SILVERSTEIN. Yes, sir.

Mr. MCDONOUGH. Can this go to the moon?

Dr. SILVERSTEIN. No, sir. This vehicle basically is a satellite vehicle. It could fire to the moon, although currently as we look at the program we would not expect to use this vehicle for that purpose.

Mr. SISK. This will be used normally in 300- to 500-mile orbits. Is that right?

Dr. SILVERSTEIN. Largely, sir.

Mr. SISK. Does the gentleman from Indiana have any questions regarding the Scout?

Mr. ROUSH. If this is as factual as you anticipate, which vehicles will you drop, if any?

Dr. SILVERSTEIN. We will discontinue the use of, for example, the Juno II vehicles. We will discontinue the use of the Vanguard vehicles, discontinue the use of the early Thor-Able type vehicles.

Mr. WILCOVE. Mr. Chairman.

Mr. SISK. Consultant.

Mr. WILCOVE. Do we understand there will be no additional cost on the Scout vehicle beyond the money being allotted here for the prototype?

Dr. SILVERSTEIN. It is not intended to, sir. This is the estimate for completion.

Mr. SISK. What is the pleasure of the committee regarding the $2 million request for Scout?

Mr. MCDONOUGH. What amount of existing funds will be dropped, as far as Juno and others are concerned if you continue the development of the Scout vehicle?

Dr. SILVERSTEIN. We have a program leading up to the time at which this vehicle will be available, and it includes Junos. But once this vehicle will be developed, we will not continue it further. We have already adjusted the program so the timing of it is correct.

Mr. MCDONOUGH. I have no further questions.

Mr. SISK. Without objection, then, the program for Scout will receive the subcommittee's recommendation, in the amount of $2 million.

Now we move to the Delta vehicle, where you had $13,800,000 in 1959, and you are requesting $13,300,000 for 1960. Dr. Silverstein, if you would, give us all the information you can, as I have already suggested, on this vehicle. As I recall, there was more discussion on all these other vehicles in the general hearings than there was on this particular one. Maybe my memory fails me. I think I probably remember less about any discussion of Delta than I do any of the other vehicles.

Mr. MCDONOUGH. Do you have any charts with you on this?

Dr. SILVERSTEIN. No. We have a chart on the Delta, which I can show you, but we do not have it with us.

The Delta vehicle is a vehicle made up of three stages. The first stage is the Thor. This is the intermediate-range ballistic missile unit.

The second stage of the vehicle is the Vanguard second stage modified slightly to provide for a steel engine instead of an aluminum engine.

The third stage is an ABL–248 rocket, which is a rocket that has been used in some of the Thor-Able programs. It was used in the Pioneer and is a fairly well-developed rocket by now.

This vehicle differs from vehicles that we have used in the past in three major ways it provides what we call coast control so we can inject the satellite very accurately into orbit.

If you will recall, in the vehicles we have fired in our program to date there have been widespread differences between the altitudes of the so-called perigee of the orbit and the apogee, the closest distance to the earth and the furthest distance. We are very interested in

being able to provide very accurate circular orbits. To accomplish this, we need two things: One is a good guidance system that will guide it into orbit, and second, we need to have this coast control feature, which means that during the time the payload is being taken to the injection altitude it is being guided along the path all the way.

The third significant change here is we have put a very large spintable in the top of this vehicle so we can carry loads up to 500 pounds in the vehicle which will give us a capability now of very accurately injecting into circular orbit loads up to about 450, possibly 500 pounds. It is an intermediate vehicle, one which we are counting on very heavily for use in our scientific program and in the early stages of our meteorological communications program. I look upon this as being our workhorse vehicle of the second type—the first type being the Scout, Thor, Delta the second.

Mr. McDonough. How close to launching is this program?

Dr. Silverstein. This program is currently underway. We have a contract for it with the Douglas Co. The funds we show here for 1959 are being committed in this contract. The funds for 1960 are to be committed in addition. This provides 12 vehicles in the program. These 12 vehicles, I think, were outlined in the chart I presented to you in executive session.

Mr. McDonough. There will be 12 duplicate vehicles built with the $13,300,000 of this year's request?

Dr. Silverstein. Plus the $13.8 million of the 1959 funds.

Mr. McDonough. Do we need 12?

Dr. Silverstein. Yes, sir. To meet the program that we have laid on along the lines I have outlined—here, I do not know if you have seen the program. Were you at the session where we presented the program?

Mr. McDonough. I do not think so for Delta.

Mr. Sisk. As I recall, of course, your reasons for requesting this number had to do with a number of experiments—if you want to call them experiments—or a number of studies or pieces of information that you would be seeking from the various shots. Is that right?

Dr. Silverstein. That is right.

Mr. Sisk. Plus the fact, of course, they have to account for the possibility of some failures, I suppose. We hope there are not any, but there is always the possibility.

Dr. Silverstein. Our program was outlined including the work in the space sciences, meteorological, communications, the applied usages. Within each of these frameworks we have certain experiments that were illustrated in some of the presentations to the committee. In the science field for example you will recall there were five areas of work to be accomplished. These vehicles are used in that program.

Mr. McDonough. Where will these be launched from?

Dr. Silverstein. Some of these will be launched from Canaveral and some from the west coast—the Pacific Missile Range at Point Arguello.

Our main program for the next several years rests basically on the Delta vehicle. It is the mainspring of our program for the next 2 years.

Mr. McDonough. Do I understand, then, for 12 vehicles, you are asking for $27,100,000?

Dr. SILVERSTEIN. Yes, sir, for the development and the hardware for these 12 vehicles.

Mr. MCDONOUGH. That is at the rate of a little more than $2 million apiece.

Dr. SILVERSTEIN. Correct, sir.

Mr. MCDONOUGH. That is less costly than the Scout, is it not?

Dr. SILVERSTEIN. No.

Mr. MCDONOUGH. How many Scouts do you get out of this?

Dr. SILVERSTEIN. There were eight Scouts in that program.

Mr. HALL. I believe you said that you would use the Thor-Able and Vanguard vehicles in this hardware here, in the Delta. Is that right?

Dr. SILVERSTEIN. Yes. We are utilizing the existing hardware to the best advantage possible.

Mr. HALL. Were those not two of the ones that Scout was to replace?

Dr. SILVERSTEIN. The Thor-Able and Vanguard as vehicle systems are being replaced. This particular vehicle has more capability than the current vehicles because of gross improvements in the guidance and vehicle system.

Mr. HALL. So actually you are not abandoning those.

Dr. SILVERSTEIN. You might say we are modifying them.

Mr. MCDONOUGH. What will be the purpose of this vehicle once it is in orbit?

Dr. SILVERSTEIN. It will have many purposes. It will be used on many experiments, some of the scientific experiments, some of the meteorological experiments, some of the communication experiments. We have a lineup of the particular experiments here if you would like to hear them. The first usage for this will be to put up the 100-foot sphere which we are going to use in our communications work. The second mission we show here is for a lunar hard landing.

The third one is a meteorological satellite.

Mr. MCDONOUGH. Did you say for lunar hard landing?

Dr. SILVERSTEIN. Yes, sir.

Mr. MCDONOUGH. But you indicate this is not a high orbit vehicle.

Dr. SILVERSTEIN. I think I made that comment on the Scout, sir.

Mr. MCDONOUGH. I beg your pardon.

Dr. SILVERSTEIN. The fourth vehicle is for a space probe.

Mr. ROUSH. What was your third one, Doctor?

Dr. SILVESTEIN. The third one was for meteorological work. The fifth one was a backup vehicle for the lunar hard landing.

The sixth one is for a thousand-mile orbit communications sphere.

The seventh one is for solar spectroscopy.

The eighth one is for atmospheric structure.

The ninth one is for a backup on the communications sphere.

The 10th one is for geodetic and avocation satellite.

The 11th one is for a topside ionosphere experiment, and the 12th one is a communications experiment.

We have lined these experiments in all of these vehicles. Our program is hung on this development.

Mr. SISK. In other words, the capabilities that you expect from the Delta vehicle, then, will form the basis for quite a number of the more immediate projects that you have in mind—that is, so far as the experiments and the information that you seek are concerned.

Dr. SILVERSTEIN. Yes, sir.

Mr. SISK. It is a vehicle, let us say, that is in the immediate future. The use of the Delta vehicle is in the comparatively immediate future as compared to Vega and some of the others. Is that right?

Dr. SILVERSTEIN. Yes, sir. We expect that our first vehicle will be fired maybe late this fall.

Mr. MCDONOUGH. How large a vehicle is this?

Dr. SILVERSTEIN. Are you familiar with the size of the Thor booster?

Mr. MCDONOUGH. Yes.

Dr. SILVERSTEIN. It is about 1.75 times the height of the Thor booster.

Mr. SISK. To what extent does the Thor in capability exceed the capability of the Jupiter in the use of these particular vehicles? Actually, the Thor and the Jupiter were, originally, generally used for the same class of vehicles, were they not?

Dr. SILVERSTEIN. Intended for the same general class.

Mr. SISK. That was my understanding. Why is it, I believe almost a hundred percent throughout your program you are going to the use of the Thor rather than the use of the Jupiter?

Dr. SILVERSTEIN. The Thor was used here because there was a lead-up to this vehicle. As pointed out in our early discussion here, this is a modification of the able configuration that was used for Thor. It was very much less expensive to start from where the art had gone rather than starting over again.

Mr. SISK. Is it not a fact, from the standpoint of actual accomplishment—and you can correct me if I am wrong—in past work, that the Jupiter has proven to be one of the most reliable of all vehicles? That is, it has a record of more successful firings than any other comparable vehicle. Is that not correct?

Dr. SILVERSTEIN. It has a very good record. I do not think I am in a position to compare these records exactly. I might say the Thor has an excellent record, too.

Mr. SISK. There has been some question, frankly, from time to time, as to just why all the emphasis was placed on the Thor when actually the Jupiter was the vehicle that permitted us to offset some Russian propaganda.

Dr. SILVERSTEIN. We have right now eight Jupiters in our program.

Mr. SISK. I recall in your overall program that there were some Jupiters in it. I was just simply curious as to why the more or less definite setup here. As I understand your explanation now, it is because the Thor is more adaptable to the particular vehicle that you have in mind for this program than the Jupiter.

Dr. SILVERSTEIN. I phrased it a little differently in saying that it had been more nearly adapted to this type of vehicle already, so that the additional modifications we are making are more economical in this process.

Mr. MCDONOUGH. There is one item here under operations and technical services in the breakdown of this cost entitled "Range and launching services, $5 million."

Dr. SILVERSTEIN. Yes, sir.

Mr. MCDONOUGH. What is that?

Dr. SILVERSTEIN. In a contract such as this, because of the fact that the Douglas Co. who fire the Thor have launching groups and great experience in launching this basic booster, we buy the services of their launching groups for firing the vehicles. This avoids the necessity for us setting up a new group, say at Canaveral, to do the launch operation.

Mr. MCDONOUGH. You mean you contract their crew to go to Canaveral or to Vandenberg to set the stage and get the rocket ready to fire?

Dr. SILVERSTEIN. Yes, sir, they have been doing this in firing the Thor IRBM's and have all the experience required to do it and it makes awfully good sense from the national point of view to continue to use this experienced group in this area that requires very highly skilled people.

Mr. MCDONOUGH. Are we developing our own crews to do this?

Dr. SILVERSTEIN. I would say for this particular vehicle during its lifetime we should continue to use the industrial team, it is a very much better process.

Mr. MCDONOUGH. Will the $5 million provide the launching and range services for the 12 vehicles?

Dr. SILVERSTEIN. For the 12 vehicles, sir.

Mr. MCDONOUGH. Is that a standard cost for the launching of each one?

Dr. SILVERSTEIN. It could be looked upon that way. These costs are pretty well established now because there is a lot of experience in the firing of these vehicles. There are certain numbers of people involved and certain range costs that are pretty well established. These figures are quite firm.

Mr. HALL. We are going to be asked this question on the House floor. You say the Thor-Able, the Jupiter, and the Vanguard vehicles are being replaced. What money do you have on any one of those three programs, or all three of them? How much additional money have you asked for those three programs?

Dr. SILVERSTEIN. For our 1960, budget, that we are presenting here, there is a total, I think, of $4 million in the satellite program for all of those vehicles.

Mr. HALL. That is in addition to what you are requesting for Delta and for Scout, which are also intended to replace certain of these same vehicles?

Dr. SILVERSTEIN. Yes, sir. That $4 million is actually final payment on vehicles that we have in our program right now. That includes the final launching cost for these vehicles. This will not occur until the 1960 period.

Our program is a continuing thing. It goes ahead.

Mr. HALL. I was trying to find out where the cut-off point was going to be. You use the word "replace." That is the reason I called it to your attention. When does the replacement actually take place?

Dr. SILVERSTEIN. The last date on which we fire——

Mr. HALL. I am talking about from a budgetary standpoint, not from a calendar standpoint.

Dr. SILVERSTEIN. The replacement will occur, then, in the 1960 budget.

Mr. HALL. In the 1960 budget.

Dr. SILVERSTEIN. Yes.

Mr. MCDONOUGH. In other words, there will be no money in 1960 for Jupiter C and the others, and for Juno?

Dr. SILVERSTEIN. There is a total of $4 million to complete this program.

Mr. HALL. That is in addition to this $13,300,000.

Dr. SILVERSTEIN. This $13,300,000 is paying your way ahead, and the $4 million completes the funds we have spent in the past year for the launchings we have scheduled. This is a continuing program.

Mr. SISK. Does the gentleman from North Carolina have further questions?

Mr. HALL. No.

Mr. SISK. Does the gentleman from Indiana have any questions?

Mr. ROUSH. I believe not.

Mr. SISK. Consultant?

Mr. WILCOVE. Doctor, in the one space probe you have scheduled, what is your goal for that? I believe you have one space probe outlined among the 12 objectives.

Dr. SILVERSTEIN. Yes; that is cosmic ray measure.

Mr. SISK. Are there any further questions now with reference to the Delta vehicle? If you will, let the Chair discuss for just a moment how we propose to proceed to finish up here.

The Chair had hoped that we would finish our public hearings this morning and that this afternoon, if it is satisfactory to the subcommittee, that we sit in executive session for the purposes of any further questions that the committee might have, particularly with reference to the Vega and Centaur programs. I think if it is all right with the subcommittee, we will pass over any formal action on the Delta, Vega, and Centaur programs this morning. Then this afternoon—can everyone, by the way, be available this afternoon at 2:30?

Will Mr. Riehlman be back in town for this afternoon or do you know?

Mr. EDWARDS. I cannot give you a definite answer, but it is a possibility.

Dr. SILVERSTEIN. Mr. Chairman, I might point out in this whole vehicle program we are going over right now this program is the thing that we called the national program, you know, and has been put together as a result of the combined action of the military services and NASA. It was prepared in a joint paper by them, including the Delta, the Vega, and the Centaur, and of course the advanced vehicles beyond this point.

Mr. SISK. Can the NASA people be available this afternoon at 2:30?

Dr. SILVERSTEIN. Yes, sir.

Mr. SISK. We would hope to actually complete our discussion this afternoon. I know you people will be anxious to complete it, and the subcommittee would like to very much, if possible, in order to be in a position to report to the full committee.

Are there any further questions on Delta, then, before we go to the next item, which is Vega?

The House will be going in session in about 5 minutes. I would like to adjourn at noon today.

I wonder, Dr. Silverstein, if you could sum up briefly as much information as can possibly be given here to the public on these vehicles? I realize that some of the previous testimony we have already had was in executive session, and of course there are certain classified aspects about these programs. But I wish you could, briefly, give us what you can and differentiate as much as possible between those two vehicles. Just combine a statement on the two, if you can.

Dr. SILVERSTEIN. These vehicles are the next round of space vehicles. They will carry payloads that are comparable to those that were put up in the lunik vehicle. The Vega, using conventional propellants—that is, the liquid oxygen and kerosene propellants, aimed at a very early capability to bring this national capability of ours up to the highest level possible as early as possible.

The Vega is aimed toward a flight within about 15 to 16 months which we hope to be able to accomplish. It is a very early schedule and we are pushing this program very hard to accomplish it.

The Centaur program is the program in which we introduce the advance technology of hydrogen fuel into our program for the first time. As we move along in this program we see quite clearly that this technology will enable us in a little more distant future to take the payloads into deep space that we visualize. It is the kind of thing upon which our whole future technology, I think, rests—that is, the development of an early capability with these high-energy propellants.

We are moving with this program as rapidly as we know how. There is an urgent military need in the communications field. We are having that available at an early date because they are interested and they have a payload.

Mr. MCDONOUGH. These are both manned vehicles?

Dr. SILVERSTEIN. Initially they will handle unmanned payloads. They will be available for advanced stages of the manned vehicle equipment.

Mr. WILCOVE. Did you say one-man vehicles initially?

Dr. SILVERSTEIN. Unmanned. In a vehicle development, I think most of us recognize that our first payloads will always be without men until the vehicle development reaches the point at which we are fairly sure we can get reliability.

Mr. MCDONOUGH. Will you fire any of these two vehicles before you fire a Mercury?

Dr. SILVERSTEIN. The Mercury program will be in progress during the development of this vehicle.

Mr. MCDONOUGH. But these are not for manned vehicles?

Dr. SILVERSTEIN. They will have the capability to boost manned vehicles into space.

Mr. SISK. The development of these vehicles is not predicated upon carrying a man essentially in the beginning. Is that right? That is, they have another purpose and another objective?

Dr. SILVERSTEIN. They have multiple purposes. One of these purposes will be for advanced vehicles to carry men, but there are other purposes, too.

Mr. MCDONOUGH. Of course, if we anticipate that a total area in which we can investigate space and attempt to build prototypes or

experimental vehicles to investigate all of those things, we will have a very big and costly program. What I am thinking about is this: To do those things that are most immediate and most essential from the scientific standpoint and to acquire additional military intelligence as a result of it will be costly. In order to justify this to the taxpaying public, we have got to do it most economically.

Dr. SILVERSTEIN. I think our taxpaying public would probably like us to get a capability equal to that which the Russians have already demonstrated at as early as possible date. The Vega vehicle here will be the first vehicle we will have that will have that capability. I for one feel that it is urgent that we build our booster capability up to this level as soon as we can. In all the comparisons that have been made, of course, we have pointed out that this is our current weakness, that we do not have this booster capability. The Vega vehicle provides the first vehicle with a capability equal to that which has already been demonstrated by the Russians.

Mr. MCDONOUGH. When you say a booster capability, you mean a propulsion after the initial thrust?

Dr. SILVERSTEIN. That is one way of phrasing it, sir.

Mr. MCDONOUGH. The booster capability is not the initial thrust then?

Dr. SILVERSTEIN. Not necessarily. It is the total thrust, the total application of energy to the payload.

Mr. MCDONOUGH. We are going to develop the million-pound thrust. That is the original thrust, is it not, we are talking about?

Dr. SILVERSTEIN. That is the cost of the initial booster, but the time scale here is such that I am sure, as we look at this program in the face, that we cannot wait 6 years to develop the capability that is equal to that which has already been demonstrated.

Mr. SISK. Actually, what we are talking about here are certain clusters and a certain use of vehicles that are much nearer from a standpoint of being usable than the single-barrel engine now, as I understand them. Am I right or wrong?

Dr. SILVERSTEIN. Yes, sir. The time period on the engine itself is around 4 years. The time period for the vehicle and its development will be a year or two after that. This, of course, has greater capability. But even so, I doubt whether we will be able to wait that long.

Mr. SISK. You are talking of the million-pound thrust engine which we have already discussed?

Dr. SILVERSTEIN. Yes, sir.

Mr. SISK. But these vehicles are not predicated, as I understand, on the million-pound thrust engine?

Dr. SILVERSTEIN. They are not.

Mr. HALL. This particular one is not?

Dr. SILVERSTEIN. The Vega is not, the Vega uses the Atlas, which is already in being, and builds a second stage which uses an engine that is in being, and which we are basically adapting to a new purpose. We probably ought to put those charts aboard and take another look at these vehicles.

Mr. SISK. Would you, this afternoon if it is not too inconvenient, bring along your charts, particularly on the Vega and the Centaur. Give us all the information you can on those because there is included

for them $84 million—in fact, almost half of what we are going to have to justify. If it is all right with the subcommittee, let us take a pretty good look at that so that although I understand quite a bit of it may be classified, we can be convinced in our own minds as to the objectives to be attained and the time element involved and on that then make our decision.

It is 5 minutes after 12. Are there any other questions which the committee would like to ask in public session, because the Chair anticipates then this will be an executive session this afternoon.

Mr. WILCOVE. Mr. Chairman?

Mr. SISK. Consultant.

Mr. WILCOVE. I would like to ask, what do you estimate will be the cost for these two programs?

Dr. SILVERSTEIN. Total cost?

Mr. WILCOVE. Yes.

Dr. SILVERSTEIN. The total cost for the programs I have——

Mr. WILCOVE. Take Vega first.

Dr. SILVERSTEIN. It is estimated that the Vega program which has been funded in the amount of $22.8 million in 1959 and for which we are asking for $42.8 million in 1960, will cost an additional $26 million spread over 1961 and 1962, adding up to a total of about $91.6 million for eight vehicles fired. That is the cost of the development and the vehicles.

Mr. WILCOVE. And the Centaur?

Dr. SILVERSTEIN. The Centaur is being funded in 1959 with $22 million. We are asking for $41 million in 1960. It is estimated that there is an additional $32.5 million in 1961 and 1962, leading to an overall cost of $95.5 million for six vehicles, including the launching.

Mr. WILCOVE. You mentioned $22 million in 1959. Those are the funds that were expended by ARPA?

Dr. SILVERSTEIN. Those are the funds expended by ARPA. This program is currently being transferred to the NASA.

Mr. WILCOVE. The $95½ million includes the $22 million?

Dr. SILVERSTEIN. It does.

Mr. WILCOVE. Is ARPA making any contribution in 1960, as far as funds are concerned, to the NASA program?

Dr. SILVERSTEIN. No, sir.

Mr. SISK. Are there any other questions? If not, the subcommittee stands recessed until 2:30 this afternoon in this room.

(Whereupon, at 12:08 p.m., the subcommittee was recessed, to reconvene in executive session at 2:30 p.m., the same day.)

1960 NASA AUTHORIZATION

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON SPACE PROBLEMS AND LIFE SCIENCES
(SUBCOMMITTEE No. 4),
Washington, D.C., Monday, April 27, 1959.

EXECUTIVE SESSION

The subcommittee met at 2:45 p.m., in room B–214, New House Office Building, Hon. B. F. Sisk (chairman of the subcommittee) presiding.

Mr. SISK. The committee will come to order for the further consideration of our budget items.

Dr. Silverstein, we have pretty well completed our discussion on Scout and on Delta. If there are any questions that might be considered to be classified on these two——

Mr. MCDONOUGH. Are we in executive session?

Mr. SISK. We are now in executive session. If there are any questions regarding the Delta vehicle or the Scout vehicle of a classified nature, we will consider those first before we start with the presentation on Vega regarding the classified material on it.

Mr. MCDONOUGH. The only question I have is of whether we should obligate ourselves for 12 vehicles at this time. We have got to try for economy wherever we can here with a maximum operation and determine whether we will get the full significance of what we are looking for without 12.

As I get the picture here, they are costing a little more than $2 million apiece. Could we get along with 10? I realize the full amount you are asking for is in accord with the President's budget. You haven't exceeded that in the full amount you are asking for.

Dr. SILVERSTEIN. No.

Mr. MCDONOUGH. But when I look at the complete picture here of the obligations being approved by this Congress, it is clear that we are going to exceed the President's budget some place along the line. As a matter of fact, if we consider some of the bills that are about ready to be reported out of other committees, they are going to exceed the President's budget.

I have a full appreciation of your responsibilities and I am very much interested in the whole scientific progress that is being made here. Nevertheless, I am wondering if we could get along with 10 vehicles here instead of 12, and not cripple ourselves too much.

Dr. SILVERSTEIN. The program we have here, of course, is a program that has a specific object for every flight. These objects that we have picked for tests are the ones that we consider are very important

to carry along the work. They cover so many areas of work that we will find, for example, there will be rather large spacings of as long as a year in any given field between the time we make one test in this area and the next.

Mr. McDonough. Let me understand this: Do you mean to say if you had the authority to go ahead with the 12 vehicles, you wouldn't fire all 12 in the next fiscal year?

Dr. Silverstein. * * * There is a leadtime in these vehicle programs associated with building up this hardware and building up the boosters. So there is a year's leadtime from the time you start until you get your vehicles. * * *

Mr. McDonough. Does that mean with the amount of money you are asking for here, you will have had enough money to build and implement 12 vehicles and fire them with this money?

Dr. Silverstein. Yes, sir.

Mr. McDonough. So that in the next budget you will not require any funds for Vega as far as the 12 vehicles are concerned?

Dr. Silverstein. In the next budget—and we are talking about Delta, aren't we?

Mr. McDonough. Delta, I mean.

Dr. Silverstein. Yes—in the next budget we have to build up our capability for the year beyond. There has always got to be a leadtime in our budget because of the time required between the time the funds are committed and the time final hardware comes through.

So what we do in our process here is to establish a program of scientifically useful applications for satellites—communications, meteorology, navigation—and then lay down the firing program required to support this program. * * *

Mr. McDonough. Do you anticipate that some of the scientific knowledge that you get from one of the satellites may provide some of the same information you get from another firing? Are they so different? The difference is in the instruments you put in the head, isn't it?

Dr. Silverstein. Yes, sir.

Mr. McDonough. The supporting material is the same in every case.

Dr. Silverstein. The booster, yes.

Mr. McDonough. It is the material that you put in the head that gives you the information. I want to be certain that there isn't any overlapping of scientific information. How can you so design the head to get just that particular kind of information and not anything else? Or can you design a head that will give you two of the things you are asking for in one firing instead of two firings?

Dr. Silverstein. This is the problem of the design of instrumentation for the payload head. I think you may recall in some of the other testimony, or have seen pictures of some of the payloads, wherein as many as five different experiments are carried in one head.

Mr. McDonough. That's right.

Dr. Silverstein. With these Thor-Delta vehicles we will have some experiments in which we will carry more than one scientific experiment. Quite normally there will be one or perhaps two experiments that will occupy the principal part of the instrumentation, and there might be some secondary instrumentation.

We are using that technique, and specifically, of course, we can't learn with a given instrument head or satellite more that we put the instrumentation in to acquire.

If you remember the list that I mentioned here, we have a wide range of subject matter covered by these 12 vehicles. I read the list earlier.

Mr. McDONOUGH. Read it again.

Dr. SILVERSTEIN. The first one has this 100-foot sphere, which is a preliminary experiment with the communications satellite.

Mr. McDONOUGH. That is a balloon that inflates after you shoot it up?

Dr. SILVERSTEIN. Yes. * * *

Mr. SISK. That is what I meant, accidentally. That is the point. We have been shooting in the vicinity of it or attempting to.

Dr. SILVERSTEIN. Exactly.

Mr. SISK. * * *

Mr. McDONOUGH. * * *

Dr. SILVERSTEIN. That is a nice way of saying it because, you see, as we move along in this technical field we are developing confidence. We are getting better guidance systems. We have to start putting these into the vehicles to do the things we want to do.

Mr. McDONOUGH. Now, Doctor, you say that the balloon is for communications perfection.

Dr. SILVERSTEIN. Yes.

Mr. McDONOUGH. Don't we have communications pretty well perfected? Why shouldn't we try to reach the moon first?

Dr. SILVERSTEIN. Again, we have certain constraints in our program. One of course is the availability of vehicles. We are talking about getting this at the earliest possible time. The package for the 100-foot sphere is a little further along right now than the other package so we will do it first. * * *

Mr. McDONOUGH. Has there been any observation made that the moon has been hit by Russia?

Dr. SILVERSTEIN. None to my knowledge at all.

Mr. McDONOUGH. The closest they came was within 4,600 miles?

Dr. SILVERSTEIN. This is their statement.

Mr. McDONOUGH. We didn't track that accurately. That was the one that went off into deep space and was lost?

Dr. SILVERSTEIN. Went into deep space, yes. We had some tracking information on it—not as good as we do on our own.

Mr. McDONOUGH. That was the one concerning which there was a question about tracking?

Dr. SILVERSTEIN. Yes.

Mr. McDONOUGH. The closest we came to it with our guidance system was what?

Dr. SILVERSTEIN. 37,000 miles.

* * * * * * *

Mr. WILCOVE. Mr. McDonough, may I ask, When is your ETA on this moon landing?

Mr. McDONOUGH. What is ETA?

Mr. WILCOVE. Estimated time of arrival. To pinpoint it a little more, when do you expect to do it?

* * * * * * *

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Mr. SISK. That at the present time is classified information, I assume—that is, to the extent we don't want to broadcast any time schedule around here?

Dr. SILVERSTEIN. Yes, classified—not really classified, but I would say official information. I think we discussed this in one of our open meetings. It has been our feeling that the overadvertising of flights works to the detriment of the national program.

* * * * * * *

Mr. MCDONOUGH. What elevation will that be in?

Dr. SILVERSTEIN. That will be in a 400-mile orbit.

Mr. MCDONOUGH. What is the life of that satellite?

Dr. SILVERSTEIN. That will be rather an extended life.

Mr. MCDONOUGH. And in a more perfect orbit than we have at the present time?

Dr. SILVERSTEIN. Yes.

Mr. MCDONOUGH. Is that because of guidance—the perfect orbit?

Dr. SILVERSTEIN. The guidance will help us put it into a circular orbit.

Mr. MCDONOUGH. Up to now what have we learned on meteorological studies with the satellites we have put up?

Dr. SILVERSTEIN. We have not learned a great deal. We have had only one satellite which had the capability of making meteorological studies. Here we again had put it up with the Vanguard. We had a good flight and put it into a fairly good orbit, but the satellite itself had a slight—let's call it—wobble so that the two eyes that were looking down at the clouds were forming figures like this on the ground. We got very excellent electronic data from it, which is now being interpreted. It is a rather difficult interpretation because, instead of getting traces across the clouds as we do in a television camera, we have gotten traces that go this way and that, and have to be put together like you make maps. This is taking quite a while.

Mr. MCDONOUGH. This is radar observation?

Dr. SILVERSTEIN. These essentially were not radar in this case, but infrared cells measuring the temperature of the clouds basically and telling weather on the ground by the difference in temperature.

Mr. MCDONOUGH. How do you determine that temperature—by the intensity of the infrared?

Dr. SILVERSTEIN. The amount of the radiation from the clouds, and from the ground due to the sun's radiation striking upon them is a function of their emissivity, which is a measure of the amount of light that is reflected from them. That will appear to an infrared cell to be clouds, or ground, or water; so you can differentiate among them.

Mr. MCDONOUGH. How accurately can you determine that temperature?

Dr. SILVERSTEIN. Quite accurately from the calibration.

Mr. MCDONOUGH. The next one?

Dr. SILVERSTEIN. We have a space probe, cosmic ray, an advance package for measuring cosmic rays. This is a probe that is going to go out in space with what we call a second generation cosmic ray package. Most of our past packages have been limited in weight.

Mr. MCDONOUGH. Will that be beyond the moon?

Dr. SILVERSTEIN. This one won't go beyond the moon. This is limited to the area we are interested in, which is the first 30,000 miles.

Mr. McDONOUGH. As a strict amateur and layman, couldn't you determine that on the way to the moon with a hard landing instrument, the same hit?

Dr. SILVERSTEIN. You could, except that when we go to the moon we are going to use up this payload package with a different type of instrumentation. We have a certain number of pounds. When we want to find out something about the moon we want to find out the magnetic field in the vicinity of the moon, for example. We want to find out something about the gravitational field of the moon. These are subjects that will require the instrumentation that we have in the package.

There are many scientific areas here that need study. I think you heard Dr. Newell discuss this in the open meeting. There is a broad field of inquiry.

Mr. SISK. The Van Allen Belt will be studied to some extent in your space probe, I suppose.

Dr. SILVERSTEIN. Exactly. Of course this is important because the question about where a man will fly in space and how he will fly in space and what kind of protection he needs in space needs to be answered. We have some information on it now, but we need these more advanced studies in order to tell what types of radiation we are going to encounter. That is, whether these are electrons, protons, heavy particles, and from what direction they are coming.

Mr. McDONOUGH. Have we found out whether the Van Allen Belt varies in intensity?

Dr. SILVERSTEIN. This again is a subject area of great interest. We know that it varies some as a function of solar activity. Between the results we obtained in the Pioneer III and the Pioneer IV tests, we found that because of some solar eruptions between the two dates that there was a heavier intensity in the one than the other. So we do know it varies. But we haven't pinned that down yet. We don't know how it varies as a function of day and night completely independently of the other variations.

There are many subject areas here to be explored.

Mr. McDONOUGH. Does the Van Allen Belt have anything to do with thunderstorms on earth?

Dr. SILVERSTEIN. Well, it could. It could have something to do with them in the sense that we know that there is a charge built up between the upper air and the earth, and that clouds are charged. We don't know the process or the mechanism of it very well. This question is a very pertinent one and it is one that scientific people are trying to get an answer to.

Mr. McDONOUGH. What is the next one?

Dr. SILVERSTEIN. * * *.

Mr. McDONOUGH. A backup? I don't understand that.

Dr. SILVERSTEIN. In any program of this type if you have a failure of a vehicle such as a lunar landing, you are very interested in going ahead and making the shot so you provide a backup vehicle for which we provide another payload to be used in the event that the first vehicle goes. It is like you recall in the story of William Tell when he dropped the extra arrow said, "In case I missed the first time."

This is the backup concept.

Mr. McDONOUGH. You mean a second shot?

Dr. SILVERSTEIN. Yes.

Mr. MCDONOUGH. Then you would have two of these firings—one for a hard landing and the other would be for a second hard landing in the event the first one failed?

Dr. SILVERSTEIN. Exactly, sir.

Mr. MCDONOUGH. If the first one succeeded, you wouldn't need the second one, then.

Dr. SILVERSTEIN. If the first one succeeds, we have another payload that will be used for that vehicle. For example, we have the atmospheric satellite to go in as the experiment in the event we don't use the vehicle as a backup.

That is the first atmospheric study that we have made in the program for over a year. We might not make it then. With any finite number of vehicles going through these very extensive programs, we find it is very hard to get two experiments within any reasonable period of time because there is such a wide field to cover. There is no denseness in this program at all from the standpoint of having multiple shots—for example, our meteorological satellites are spread as much as a year apart between one experiment and the next one. The same is true in some of the other programs.

There are just so many things to learn in establishing a finite program and moving at some reasonable rate so that we don't move so fast that we can't take advantage of what we learned from the program before it.

Mr. MCDONOUGH. Mr. Chairman, I don't want to take all the time here, but I just want to review these 12 shots.

Mr. SISK. Go ahead and enumerate the balance of them. I think you have given six.

Dr. SILVERSTEIN. The seventh is solar spectroscopy. The sun is the source of all the energy that comes onto the earth. Here we are going to make a very detailed study of the radiation from the sun with different sorts of instrumentation.

The next one is in 1961—January 1961—with an elliptical orbit to study the atmospheric structure. It relates again to weather applications and trying to find out what the variations are with day and night, month to month. It will stay up for quite some time—highly instrumented.

Mr. HALL. Would that not be the same one you would use as the backup vehicle in the event the moon shot is successful?

Dr. SILVERSTEIN. No; it would not be because the payload here is a more advanced payload. It is in a period about 6 months afterwards. The first one has about half its payload taken up with the radiation equipment, so it wouldn't be the same payload. It is an advanced one.

The ninth vehicle here is the second communication sphere, the 100-foot sphere.

Mr. MCDONOUGH. Similar to the first one?

Dr. SILVERSTEIN. It is similar to the first one, but it occurs * * * when our ground stations are developed to the point where we can make more adequate use of it. With our first one, we are going to make a study by reflecting a ray from the east to the west coast to find out the best frequencies and the types of ground equipment needed.

For the second one, we will make use of all the information we have learned in the first shot and develop the ground equipment to take it to the next step. This is the process by which we do this work.

The next object here, the tenth one, is a geodetic and navigation satellite. This is a satellite with a combination of a beacon and a very powerful flashing light.

Mr. McDONOUGH. For more accurate geography?

Dr. SILVERSTEIN. Yes, sir; and for guides and navigation.

The next one is an ionosphere satellite. Here, I don't know whether you recall Homer Newell's presentation on the ionosphere, which is important because it is several electrified layers that are important to ground communications.

Mr. McDONOUGH. Why is that layer important? Is that a bouncing cushion?

Dr. SILVERSTEIN. It serves as a reflecting layer. It is electrified, you see. As a result of the sun's rays hitting this layer, it becomes electrified. When this becomes electrified, the electromagnetic radiation which moves up into the atmosphere, as a result say of a signal from the ground, hits it and it is reflected from the surface and currently long-wave radiation—20 megacycles—can be reflected a good part of the way around the world by bouncing from the ionosphere.

Mr. McDONOUGH. Is that constant?

Dr. SILVERSTEIN. It is not constant, either in type or intensity. For example, it is different in the day and in the night. You know that there is a difference——

Mr. McDONOUGH. Is it better in the nighttime than in the daytime?

Dr. SILVERSTEIN. There are two significant layers in the nighttime and in the daytime the layers are split more.

Mr. McDONOUGH. Is that the reason we get better radio reception at night than we do in the daytime?

Dr. SILVERSTEIN. It is one of the important reasons, yes, sir. The next firing is in * * *. It is a communications satellite, but here we are going to use a different type of communications system, one with a beacon aboard instead of a reflector type. The earlier one is called a passive system and this one is called an active system.

What we will be attempting to do here is to get a broadband repeater sending set in the satellite, particularly aimed at the concept of developing satellite television concepts, the adapting of the satellite to transmission of television. That is why you need the broadband.

Mr. McDONOUGH. In other words, most of the money then for this item will be for the instrumentation in the head because your supporting propulsion equipment will be the same in most cases, won't it?

Dr. SILVERSTEIN. The moneys in the Delta item are all for the development of the propulsion system and the purchase of these 12 units. The funds to carry the instrumentation and these packages themselves are in the budget and are shown earlier. They are handled by another committee.

This is all for propulsion. These are all for propulsion, yes.

Mr. McDONOUGH. Won't we learn in 12 firings to economize in that propulsion? Certainly, as we shoot the first of them, we are going to find a lot of things about it so that by the time we shoot the 12th one we will know things about it that we didn't know about the first one.

Dr. SILVERSTEIN. I hope we will, sir. This vehicle should perform quite well. Those of you who have been familiar with the missile de-

velopment picture know that it takes some time to be sure that the vehicle is operating properly. We are hoping that because we have used in this vehicle existing things such as Thors, which have reached a rather good state of reliability now, engines that are fairly well developed, that we can hope to have quite good performance from the combination. But again you can't be sure of this. It takes development time.

Mr. McDonough. Are those solid propulsion units?

Dr. Silverstein. These are all liquids, all except the top stages, which are solid—the ABL–248.

Mr. McDonough. Is there any questions about the source of material for these propulsion liquids?

Dr. Silverstein. In this case, of course, we are using the same liquids that are currently being used. They are conventional—lox (liquid oxygen) and rocket fuel, RP–1.

Mr. McDonough. In other words, there is no question about the quantity available?

Dr. Silverstein. No, sir.

Mr. McDonough. We can make it any time we want, in any quantity we want?

Dr. Silverstein. Yes, sir.

Mr. Sisk. Does that complete your list on Delta now?

Dr. Silverstein. That does, sir.

Mr. Sisk. Let's move now, then, to your presentation. Please give us a brief presentation on the objectives to be achieved and as much of your long-range program as you have projected into the future, how soon you expect the Vega to accomplish its purposes, and so forth, and what those purposes are, Dr. Silverstein.

Dr. Silverstein. May I ask if Mr. Hyatt can describe these charts again so as to bring us all up to date to the description of the vehicles?

Mr. Sisk. Fine. Proceed.

Mr. Hyatt. I will show quickly the difference in appearance between the Vega and the Atlas on which it is based. There is the Atlas on your left. Its height is about 81 feet. Notice that the Vega is higher. Also notice that the Atlas at some point in its height here is tapered down and then the warhead fits on top.

Here we have to modify the Atlas, make it straight. This is a 10-foot diameter here. Then we set the Vega stage, which is the second stage shown here in phantom as if looking through a glass, which sits on top here. Then in some cases there might even be a third stage on there.

So that is the Vega and it shows some of the thrusts here. This thrust is exactly the same as in the Atlas vehicle. There are two main engines here, booster engines, which supply thrust partway and then they drop off. Then the middle engine, called the sustainer engine, continues to supply thrust to the main stage. Eventually, after all this fuel is burned out, it drops off and then the second stage is fired and provides the thrust to the payload. If it has a third stage, then at some point in the trajectory the second stage drops off and the third stage carries on.

It is this second stage and the modification of this——

Mr. McDonough. You are describing the third one there?

Mr. HYATT. This is the second. Notice that it looks different from the Atlas because we have widened it out. The Atlas tapers off here. This has been widened out to be the same diameter all the way up, 10 feet. Similarly, the second stage is built to a 10-foot diameter. One sits on top of the other.

So, as I say, to describe the trajectory, the entire vehicle is launched. All the three engines would be burning at launch. Sometime during the trajectory the portion right here with the two outer engines would drop off. The other engine continues to burn until all the fuel is eliminated. Then it drops off and the second stage is fired. So we can use the vehicle in two ways: One, as a two-stage, in which case the payload would be on top of the second stage; or we can use it as a three-stage, in which case, in addition to the second stage, we would put another propulsion stage on top and then put a payload on top of that.

By way of numbers, this is the thrust initially of these three engines.

Mr. MCDONOUGH. That is now available?

Mr. HYATT. This is now available; yes, sir. But we do have to modify it. We have to widen it out at the top so as to fit the second stage. Here is the thrust of the second stage, and there is the weight of the second stage and everything on top of it.

If we have a third stage, there we would have a storable propellant third stage. By storable propellant, we mean that the propellants used are generally liquids at room temperature. Here the liquid oxygen is a liquid only at minus some 290° F.

But here, both of the fuels are liquids at normal temperature. By way of performance, as Dr. Silverstein said, this is the first vehicle that gives us the capability that we believe the Russians have today or have already demonstrated.

* * * * * * *

In order to make a soft landing, of course, the part of the weight that is sent out in space toward the moon has to have an additional propulsion system in it so that as it approaches the moon, it can be slowed down so it wouldn't be destroyed on hitting the moon.

So when we talk about making a soft landing here, we talk about something landing a little bit harder than if it were dropped by a parachute.

Mr. SISK. On that soft landing you are speaking of there, * * * that, of course, is strictly just an instrumented unmanned soft landing?

Mr. HYATT. Yes, sir.

Mr. SISK. It puts some instruments on the moon?

Mr. HYATT. * * *.

Mr. MCDONOUGH. Do you anticipate that if that were successful the landing would be soft enough so that the instruments would be available for communication after it landed?

Mr. HYATT. Absolutely, yes, sir.

Mr. MCDONOUGH. Not knowing the condition of the surface of the moon, you don't know whether it is going to go down into a spongy mass or a dusty mass. If it did, would you still be able to communicate with it?

Suppose the surface of the moon was just an ashen mass and it dropped into the surface of the moon 50 or 60 feet.

Mr. HYATT. Then very likely the signals would be so attenuated—so reduced in strength—that we would get nothing back.

Mr. SISK. At least we would learn, though, that the first manned flight that went over there would have this little problem to face.

Mr. HYATT. That is absolutely correct. Of course, we are thinking in terms of a rocky-type of terrain. So the landing is designed for that sort of thing.

Mr. HALL. * * *.

Mr. HYATT. Yes.

Mr. HALL. An instrument payload?

Mr. HYATT. This is a package, now. Let me describe what this package might be. First of all, it would have a container.

Mr. HALL. That doesn't include the retromotors that will have to be——

Mr. HYATT. It does not include the retromotors, no, sir.

Mr. HALL. Nor the fuel to operate them.

Mr. HYATT. Nor the fuel to operate it.

Mr. MCDONOUGH. You describe what it may contain. I would like to hear that.

Mr. HYATT. It will have an outside structure. Then there will be instruments and power supplies and antennas and so on. The instruments, for whatever purpose this experiment is being designed—I am not describing a particular experiment, but it could have magnetometers to measure the gravity of the moon. It could possibly also have instruments that would try to measure the atmosphere close to the surface of the moon.

Then there would be transmitters in it. Of course these measurements that are made are always converted to electrical pulses. Then the transmitter would send these electrical pulses back to earth. On earth they would be decoded and we would know what the instruments were reading.

Mr. MCDONOUGH. The moon is revolving now after you land there. The moon goes around. If it is on the back end of the moon, how are you going to get your impulses back?

Mr. HYATT. You will recall that the moon revolves in the same period it goes around the earth—about once every 30 days. Thus, the same side of the moon is always toward the earth. We would be able to receive impulses as long as the power source in here lasts.

Mr. MCDONOUGH. What kind of power source for transmission would you have in that head?

Mr. HYATT. Very likely there would be storage batteries.

Mr. MCDONOUGH. Now, the next one.

Mr. HYATT. This is how much weight we can send for a probe to near planets. Because of the distances involved, millions of miles—50 million to a 100 million—we feel that this weight is just about on the threshold to get us back significant information because of the power supply, all communications equipment weight, that has to be part of the payload.

The instruments possibly wouldn't weigh much more than in here, but because of the greater distances we have to have more powerful

transmitting equipment and therefore supply it with more power in order to send it back to us.

So this is the Vega. The Centaur—I will just cover up——

Mr. HALL. * * *

Mr. HYATT. Yes, that is right.

Mr. HALL. * * *

Mr. HYATT. That's right.

Mr. HALL. You spoke of a hard landing on the moon. What would a hard landing on the moon show other than that you can hit the moon?

Mr. HYATT. In terms of weight, it would be higher than this because we had to have some type of——

Mr. HALL. What is the advantage of a hard landing on the moon other than to show you can hit the moon?

Dr. SILVERSTEIN. May I answer that? In a hard landing on the moon, most of your important measurements are obtained in the process of going into the moon. It is the path in where you get your payoff.

Mr. HALL. What would be the speed at the time of impact?

Dr. SILVERSTEIN. At the time of impact the speed would be roughly 7,000 miles an hour.

Mr. HALL. So you couldn't get much information, then, at that speed, could you?

Dr. SILVERSTEIN. Not much.

Mr. HALL. So that one mainly is just for——

Dr. SILVERSTEIN. You could get information at that speed. In other words, the instrumentation is sending, of course, at the speed of light. You can get quite a bit of information because you have got a long path in. It will take over 2 days, you see, at the process at which you are flying; and as you get closer and closer, your information gets more and more interesting in this case. So you will be sending all the time and you will be gradually noting the change in the values of, say, the magnetic field, the gravitational field, and so on.

Mr. HALL. Would it coast into the moon, or would it still be pulled in by gravity and the velocity would help to get it there? Would there be any propellant or any thrust being used at the time of impact?

Dr. SILVERSTEIN. No, sir. If it is aimed properly, it will basically move strongly into the moon's gravitational field and then be pulled into the moon by the moon's field.

Mr. HALL. That is about a seventh of ours.

Mr. HYATT. It is a fifth of ours.

Dr. SILVERSTEIN. Approximately.

Mr. HYATT. Excuse me, the escape velocity is a fifth. I don't know the exact number for the gravitational field.

Dr. SILVERSTEIN. The escape velocity from the earth is around 36,000 miles an hour. The moon is around 7,000. It is a ratio of 5 to 1.

Mr. MCDONOUGH. How accurate are the reports that the moon's surface varies in temperature from 250° F. to −250° F. in one day?

Dr. SILVERSTEIN. Of course the side of the moon that is looking at the sun is going to be hot. The side that is looking away into empty space will be cold.

Mr. McDonough. Is it going to be hot?

Dr. Silverstein. It will be hot in the same sense that the earth's surface is hot. That is, looking at the moon. The atmosphere in the earth holds the heat in so that we don't get the large differences between the two sides that we get on the moon. On the moon, the atmosphere is almost nonexistent—so we believe. So if it is not looking directly at the sun, it will not hold the heat. It will simply radiate to outside space and we will get the temperature radiated in outside space, which is cold.

Mr. Sisk. So, actually, if our present studies are factual, you will have a change of 500° or 600° in temperature in almost minutes—at least a very short period of time—as the moon's face disappeared from the sun.

Dr. Silverstein. The moon points its same face toward the earth all the time except for a slight vibration of the moon, which gives you more than the same face, because it swings a little bit about its axis.

Mr. Sisk. I am speaking, though, with reference to its face which is toward the sun, not toward the earth.

Dr. Silverstein. Correct.

Mr. Sisk. All right, will you proceed now to Centaur.

Mr. Hyatt. This, by the way, is a comparison of size. The Vega is right here, the same as I just showed. This is the Centaur.

Let me just start at the bottom again. From here to here, these two vehicles are identical. The principal difference is in the second stage. In the case of Vega, the fuel is lox—liquid oxygen and RP, which is nothing but a jet fuel just like our turbojets that fly the commercial turbojet airplanes, except that it has a particular specification, and it has been termed RP–1.

So this is jet fuel and liquid oxygen. Here we have liquid hydrogen and liquid oxygen. Liquid oxygen has a liquid temperature of −297° F. Liquid hydrogen is −422° F. So that is almost 135° colder than liquid oxygen.

We have had a lot of difficulty learning how to work with liquid oxygen, how to make valves for it, how to make quick disconnects, how to operate it so that at just the proper moment, for example, about 5 minutes before launching, the vent is shut off and the pressure is allowed to build up in the tanks.

All these problems have to be learned with liquid hydrogen. They took several years to learn with liquid oxygen. Now we will have to work with temperatures of 130° to 150° colder. So you can see the technology here is a new technology.

Also, liquid hydrogen is one-sixteenth as heavy as liquid oxygen.

Mr. McDonough. The atomic weight is 1 and 16?

Mr. Hyatt. Yes. This, then, is why the tanks for the second stage of Centaur are so much larger than the tanks over here for the Vega. This is what makes the height difference, because the thrusts are about the same. * * *

Mr. McDonough. You have liquefied the hydrogen though in the laboratory?

Mr. Hyatt. Yes.

Mr. McDonough. What quantities have you done that in?

Mr. Hyatt. This has been done in thousands or millions of gallons.

Mr. McDONOUGH. Is there any other use for liquid hydrogen than as a propellant for rockets?

Mr. HYATT. Liquid hydrogen has many commercial uses. I cannot name them for you, however, at this time.

Mr. McDONOUGH. Is it shipped in commerce?

Mr. HYATT. It is shipped in Dewars, shipped in tank cars, and also by truck.

Dr. SILVERSTEIN. It is currently being shipped across country for rocket tests.

Mr. McDONOUGH. Then you must have some knowledge of the type of valves for transmission of it.

Dr. SILVERSTEIN. We have some knowledge of valves. There is a technology that has been building up in this field for the past several years. Much of it has been done by inhouse activities of NASA and some of it has been done by contract.

Mr. McDONOUGH. Is it as dangerous from an explosive point of view in its liquid state as it is in its gaseous state?

Dr. SILVERSTEIN. Normally it would gasify before it would explode. In other words, the process by which you have an explosion in all cases is to go through the gaseous phase.

Mr. McDONOUGH. You say liquid hydrogen is maintained at what temperature?

Mr. HYATT. —42° F.

Mr. McDONOUGH. What kind of tank cars do you ship that in?

Dr. SILVERSTEIN. The things are essentially Dewar bottles, vacuum sealed with, in many cases, nitrogen around the Dewar.

Mr. HYATT. You can appreciate from that statement that the ground technology is as different as day and night from a technology required to build a tank for flight. We couldn't afford to build a structure that would be so heavy that we could make a vacuum region between two walls, one inside and one outside. It is just plain too heavy. We couldn't put it off the ground.

Mr. ROUSH. Is liquid hydrogen being used in connection with the nuclear reactor?

Mr. HYATT. Yes, it is. This is another application of the hydrogen technology. There are different reasons for it, in this case we are using hydrogen with oxygen because of the high heat of reaction.

The second factor, the products of combustion are lighter. You make water when you burn hydrogen and oxygen which has a lower molecular weight than the carbon dioxide and carbon monoxide you made by burning the kerosene-lox. The net effect is of course we get this higher efficiency out of the fuels that has been discussed here several times, the higher so-called specific impulse or thrust per pound of fuel burned. This is why we are going to these more exotic fuels.

In a nuclear rocket there is a different principle. Here we use hydrogen because of its low molecular weight. Nothing happens to the hydrogen going through the nuclear reactor except it is heated up. But it is heated up to a very high temperature, say 5,000° F., coming out of a nozzle; because of the low molecular weight you get a very high thrust per pound of fuel coming out.

This is a function of the square root of temperature divided by molecular weight. If the molecular weight is low you get a very high impulse.

Mr. McDonough. When you heat that hydrogen up—of course this is a little aside from the consideration—in the nuclear operation, how do you prevent the explosion of it?

Dr. Silverstein. There is no oxygen there. It is all hydrogen. You have to be careful in handling hydrogen to avoid explosions because quite often the combination of hydrogen and oxgen will detonate so you get more than just a normal explosion, but rather a detonating explosion which give you very high pressures.

Mr. McDonough. The remarkable thing in my opinion is that there hasn't been more explosions in the handling of these very exotic fuels in the rocket plants around the country. They certainly have been cautious about that. Is liquid oxygen as explosive—it isn't as explosive as hydrogen?

Dr. Silverstein. Of course oxygen by itself won't explode. It is one of the principal constituents, you see, the air we breathe—22 percent of it is oxygen. It is in the class of materials that oxydizes. It is very definitely explosive in most places because you almost always can find some fuel to combine with it. In the liquid state, it vaporizes quite easily when it gets out—it will find a piece of wood or some oil. Oil and oxygen go up like that [illustrating].

Your lines have to be very clean. Your surroundings around the plant have to be clean.

Mr. Hyatt. That describes this vehicle. I would like just to point out in terms of its performance capability. You can increase the Vega numbers by about 50 percent. In other words, one and a half times this or any of the other numbers. This is the performance of the Centaur, even though the weight of this stage is exactly the same as the Vega, 30,000 pounds.

The reason for that is just what Dr. Silverstein has finished explaining, that is, that the specific impulse or the thrust that we get for every pound of propellant expelled through the jet is greater than it is here. That is why we can have the extra performance. * * *

Mr. Hall. We get into a whole new field, though, with this rocket?

Mr. Hyatt. Yes, we get into entirely new technology.

Mr. Hall. We have got to have the motor first.

Mr. Hyatt. We have got to have the motor, the tanks. We have got to learn how to work with them.

Mr. Hall. The thing you would work on first would be the motor actually.

Mr. Hyatt. The motor is now under contract. It is being developed by Pratt and Whitney.

Mr. Hall. That is the $102 million engine we have started on?

Mr. Hyatt. No, sir; this is a different motor; $102 million is for a big motor, the million and a half pound thrust.

Mr. Hall. Isn't this a smaller concept of the same design?

Mr. Hyatt. No, sir. * * * This is that million and a half pound thrust engine. The fuel in it initially will be RP or jet fuel, plus liquid oxygen. The engine in this second stage of Centaur burns liquid oxygen and liquid hydrogen. * * *

Mr. HALL. You are traveling too fast for me.

Dr. SILVERSTEIN. May I try for a minute here? The million and a half pound rocket we described earlier is a rocket which does not use the new technology of fuels, but is a larger rocket than the current rockets we have and does use the same fuels we are using currently. * * * and provides us with a capability in the booster stage, the first stage of the rocket. These are multistage vehicles as shown here, and this is the one that is right next to the ground, the big one that takes the load off the ground.

Now, we use these new fuels in the upper stages of the rocket, where you make big gains from them as compared to the first stage. The rockets you use in the upper stages are always smaller than the first stage rockets. So we will find that in these initial rockets we are going to develop for the use of hydrogen as a fuel, that they will be smaller than these very large rockets we are putting in as the first stage, the booster rocket.

Mr. HALL. So that the design and production of this engine has absolutely nothing to do with the million and a half pound engine that you are talking about other than that they are both rockets?

Dr. SILVERSTEIN. Yes, sir, that is exactly right.

Mr. HALL. I believe you stated that this particular engine had been tested. Is that right * * *

Dr. SILVERSTEIN. The engine here is currently under contract. In your book here, I think on about page 293, we will find the history of this rocket development. This rocket was started under a Defense Department-ARPA contract during the current year, 1959. Progress is being made currently in its development. We are following the technology here.

* * * * * * *

We take this program over in 1960 and follow it because the use of these hydrogen rockets is more particularly aimed at the deep space missions which are necessarily a part of NASA's program rather than the low altitude satellite program. So we have taken over this program.

Mr. HALL. How much money has been spent on the rocket to date?

Mr. HYATT. $9 million.

Dr. SILVERSTEIN. The current contract is for $9 million with Pratt & Whitney.

Mr. HALL. How much more is to be spent other than what is contained in this budget for the fiscal year 1960?

Dr. SILVERSTEIN. Let me make one thing clear. In our 1960 request we are asking for money both for the rocket engine—here I am differentiating between the engine and the rest of the system——

Mr. HALL. Yes, I understand.

Dr. SILVERSTEIN. And the tankage and the rest of the system.

Mr. HALL. That's right.

Dr. SILVERSTEIN. So the some $41 million we are requesting is for the rocket. The answer to your question is that the rockets in the initial part of the program which amount of six rocket systems are to be completed as a part of the $9 million we spent in 1959 and $13 million to be spent in 1960 funds.

Mr. HALL. That $13 million will come out of this $41 million?

Dr. SILVERSTEIN. It is included within the $41 million.

Mr. HALL. So you will have spent a total of $50 million in developing these six rockets?

Dr. SILVERSTEIN. More than that. We are currently in this year I think spending a total of $22 million——

Mr. HALL. I beg your pardon, I mean aside from that, it would be this $41 million plus the $9 million that had been spent in prior development of the rocket motors?

Dr. SILVERSTEIN. But there is also $13 million that is being spent this year on the tankage which has to be added to this number to be complete.

Mr. SISK. It will bring it up to $63 million?

Dr. SILVERSTEIN. $41 and $22 million, yes, sir.

Mr. HYATT. I think this completes my explanation, unless there are some more questions.

Dr. SILVERSTEIN. I would like to make a general statement here.

Mr. SISK. Yes; please make a general statement in line with what you have in mind, plus any additional ideas or plans that you have for the use of this particular vehicle. I am speaking now of Centaur.

Dr. SILVERSTEIN. Yes; I would like to say that the vehicles we show in our program are a well-thought-out development of what we have considered to be the needs of the national program. As we moved into this field after NASA was created, one of the first jobs we took on was a study of the vehicle requirements of the program, and we did this because we realized the grave shortage in this country in the whole space effort was in the vehicle program.

So we set up, together with the Defense Department, a team to study the vehicle needs looking at the programs that were required to be accomplished over a period of time and looking at the leadtimes required to develop these vehicles so that we could do what we thought the administration and Congress had set as its goal, namely, to make this country first in space.

We set this program up, recognizing that there was a need for vehicles to carry on the immediate program so that we could garner to ourselves the advanced technology required and to make gains in the science, in the technology, and the application to a satellite for useful purposes, so that this country could begin to develop the backbone and the core of the type of technology which you need to carry along for the future.

Then we set about getting ourselves advanced capability, capability which we hoped in time would build the resources of this country up to the point that we feel that it should have. This involved the development of the Vega vehicles and the Centaur vehicle. In the first case of the Vega, this vehicle will most rapidly bring us up to a capability that has already been demonstrated by the Russians around the first of this year.

We are attempting here to bring our capability up as rapidly as possible just to match it, and that is all we can do in this first phase.

Then we can go and take the next step and exceed it. But in the next step you saw more than just the slight exceeding of the capability of the Vega. We saw the whole future of this vehicle business. We realize that we are going to have to have hydrogen oxygen engines in the future, and the time to begin it is now, because this technology may be a very difficult one.

The way to uncover the problems is to work on them. We can't sit back and expect these problems to unroll by themselves. We must put them in vehicles. We must study them. We must try them. As we do this, we will begin to really understand what our problem is and how we can carry along this technology for the future.

We feel this is absolutely essential to the future development of our national program and we feel if we do not carry along this type of development that we can be accused at a later date of having failed to see the need for it and having failed to take care of it properly when we did so.

I make a very strong plea here that this type of vehicle development is absolutely necessary in the national interest and that I feel that we would be certainly derelict in not bringing it very strongly to your attention.

Mr. SISK. As I understand it, you then are saying to us, Dr. Silverstein, that in the opinion of your best experts, using their best judgment, that this is the minimum program that we can afford to move on at the present time, and that anything less than this, we would be taking some substantial chances on being accused later of failing to realize the full possibilities?

Dr. SILVERSTEIN. I feel very strongly on this point. This is absolutely correct. This is the opinion, I think—the joint opinion—of the experts in the technology of propulsion.

Mr. SISK. It is my understanding from statements by Dr. Dryden and by yourself that these figures represent those submitted by NASA originally and they were not reduced by the Budget Bureau or anyone else at a higher echelon in Government?

Dr. SILVERSTEIN. Correct, sir, these figures are, I think, in a sense rockbottom figures because, as we all know in a development of this type, you do the very best you can to estimate their costs.

But there are always things that are encountered during a development that can cost more money. We have not perhaps allowed as much in this area as we might need to to take care of it.

Mr. SISK. Let me ask you this: In the board or conference action at which you finally determined these figures, to what extent was there disagreement? To what extent were there those who felt that this was probably too little and would have preferred a substantially larger amount in, let's say, these specific programs we are talking about as well as in the overall R. & D. program?

Dr. SILVERSTEIN. I think you will find in any program development of this type that there will be various exponents of different procedures. I think I can say that this program has appealed to the good sense of most of those who have investigated it.

There are, of course, some who say that it isn't enough. They may be correct. I think judgment is involved here in some way in evaluating how you move in a program with this advanced technology. In our judgment this is a reasonable program.

Mr. SISK. That was, of course, the point I was seeking. I have been very much in favor of seeing you proceed as rapidly as you could in all good judgment—that is, taking everything into consideration. In fact, I have indicated before and I am glad to do it again, that if in this overall program more money is needed and could be efficiently used, I for one would support an additional appropriation in spite of

the fact that our budget is, let's say, very precarious. I do feel very strongly the importance of this venture in which we are involving ourselves.

At the same time, we, of course, don't want to duplicate or to throw away money, and I am sure you people do not also.

The gentleman from Indiana.

Mr. ROUSH. My question is a rather general one, and it pertains to the matter of duplication. In this particular field, are the Army, Navy or Air Force also going into the development of a vehicle of this sort? Or is this entirely your program?

Dr. SILVERSTEIN. This is the national program that has been agreed to by the Defense Department and NASA. Basically these vehicles are to be used in both programs and it is an agreed-upon program.

Mr. ROUSH. Going back to the Delta program, does the Army, Navy, or Air Force have a mission which might duplicate any of the 12 missions of that particular program—referring to the Delta program?

Dr. SILVERSTEIN. I don't know that you could say it would duplicate it. They have, for example, some communications missions that are to be flown. They are more particularly designed, however, to accomplish a given objective associated with military communications. So it is not duplication. It is another area of the field.

Mr. ROUSH. Is there a complete coordination between your office and, say, the office of the Army in this particular field of communications?

Dr. SILVERSTEIN. Rather than picking the office of the Army, may I say with ARPA, which is charged in the Department of Defense with the general conduct of space activity.

Mr. ROUSH. The reason I ask these questions is that people make many inquiries of me, I know, concerning our space program. The one thing that they seem to be critical of is that they have the impression that there is duplication of effort. If we stand on the floor of Congress to substantiate these, I think that is one question our colleagues will be asking us: Is there a duplication here? I would like to be able to stand up and say "No."

Dr. SILVERSTEIN. I think you can say this about the space program—that all of the major objects in our budget have been carefully discussed with the Department of Defense. In some cases they have been worked out mutually with them.

In this field, I think we can say that there has been a greater degree of cooperative action than I have seen before in any other program which I have been associated with. It has been quite good.

I cannot say it is perfect because none of the human systems we have established as yet have this degree of perfection that we all would like to see. It is getting better every day.

We have many panels in operation between our two groups at the working level. We have higher levels at the management level. These are continually being set up. I think as this program moves along we can assure you that there will be cooperation at every point.

We certainly want it ourselves, because it is confusing without it.

Mr. ROUSH. This particularly impressed me, Doctor, when my son gave me a gift over the weekend. It was a small board upon which he had erected plastic models, purchased commercially, of each missile

that we have. I believe there were 30-some different missiles on that board. I wondered in my own mind if it was necessary to have that many missiles when I knew of the cost of these various things.

I wondered if we are looking toward the day when there won't be quite so many of them. I felt assured in my own mind there must be some duplication of mission somewhere along the line. I was glad to hear you say this morning the Delta will replace three of these, and that this other one would replace four or five, I believe.

Dr. SILVERSTEIN. In the ballistic missile field, which is, of course, outside the range of our experience, there are many missiles. Some of these are prototypes that never reached the development stage. Others, of course, do reach the development stage. Some of this duplication which I think has occurred was due to the way in which the program had to be established. I think all of us recognize the fact that several years ago we realized that we were a little late in getting into the ballistic missile business, and that we could not really take too many chances about not being there when the time required us to be there. So several programs were set up in several of our cases—the IRBM and ICBM in order to assure ourselves that one of them would come through.

It is a fact, I think, that our technology has been good enough so that several have come through. In the space field, of course, we are taking off from where the ballistic missile field left us. We are using, for example, in this Vega and the Centaur, the Atlas missile which is a product of our technology here. I can say this, that if this space program was not able to take off from where the missile field brought us, that the expense of this program would be a great deal more than anything we bring to your attention today.

We are resting on the shoulders of this missile development and building from there up. Of course, as we are moving further down our program, we are creating the new vehicle such as the Nova vehicle which will give us a capability which does not reside now in the ballistic missile area. So it is quite fortunate, I think, that this country had the technology to build up the missile field so that when we reached the space age we did have the basic boosters that were required to do the job. This is the reason we were able to take a Juno vehicle, which was based on the Jupiter missile, which had reached a stage of development, and fired it some 4 months after we decided to move ahead using military vehicles.

Mr. MCDONOUGH. I think the public's opinion has been influenced a great deal—and it is unfortunate we have to say this—by the several failures of Vanguard. It is unusual in my opinion why we had so many failures. We certainly must have learned something about the previous firings to prevent failures following that, but nevertheless we had them.

Dr. SILVERSTEIN. In answering you, I think I should point out in any development of vehicles as complicated as these space vehicles are, there must be some failures because we do our laboratory work-out in space. In any development I think, if you have followed it, you will know that there is a debugging period. In our airplanes after we first get an airplane to fly, there is a period of a year to two years during which time we debug the airplane. This is a point at

which we take off things that are not working quite right and put other things on that work better.

The unfortunate part is that this debugging process in a space vehicle is not returnable, whereas with an airplane, when a fuel pump does not work, you can coast to a landing and put a new pump aboard. But in these vehicles when one fails to work you have lost it. This is the basic problem we are up against.

Despite that, if you go into the history of all these vehicles as we have done, you will find that the Vanguard record is as good as that of any of the ballistic missiles that were created as a result of the missile program. The failures are more prominent. Actually they are in about the same percentage—in fact the numbers look quite alike. They are almost statistical in character.

Mr. McDonough. In the Centaur program, according to the data you have here in your description, you are asking for six vehicles.

Dr. Silverstein. Yes, sir.

Mr. McDonough. That means they will cost a little more than $3 million apiece?

Dr. Silverstein. They will cost more than that, sir.

Mr. McDonough. Ten million dollars apiece, I mean.

Dr. Silverstein. More than that.

Mr. Sisk. If the gentleman will yield, of course I think, based on the dollars and cents here, it would be a little hard to put a price tag on each vehicle here. We have a round figure, but there are a lot of things involved in that figure besides the actual breakdown of the cost.

Dr. Silverstein. The development costs are in there, the initial development costs. Actually after the vehicle is developed, then they will be much less expensive.

Mr. McDonough. Do you have a special mission for each of the six?

Dr. Silverstein. Yes, sir.

Mr. Hall. You hope it will be obsolete by the time it is developed, do you not?

Dr. Silverstein. The vehicle?

Mr. Hall. Yes.

Dr. Silverstein. Actually I cannot join you in that hope right now. We hope to be able to use them.

Mr. Hall. I understand that. But I mean so far as the advance in technology and knowledge is concerned, by the time that vehicle is ready to go off the launching pad you should have acquired sufficient new knowledge to make that particular vehicle obsolete. Is that right?

Dr. Silverstein. This is the general history of vehicles. This does not usually prevent you from using it, but it does make you aware of things for the future that you are able to do now that you could not have done before. In all of our developments of this type, one of the most worthwhile results are byproducts of the thing you start out to do. The things you learn from the program are, in many cases, worth a great deal more than any anticipation that you have ahead of time of what you are going to learn from the program. This has been true over and over again in basic research and development.

Mr. Sisk. I only have one further question here. I think all in all, I might say, Dr. Silverstein, you and your people backing you up have

made a good case, at least based on a layman's knowledge of this situation. I realize we are delving in many instances into the unknown.

With reference to Centaur, it is actually the only completely new program where we are committing ourselves to spend a substantial amount of money in the vehicle field—that is, separate and apart. I realize, of course, we are already committed on the 1-million-pound-thrust engine, and we are proceeding with that as rapidly as we can. But this Centaur, we are actually taking it over, as I understand, from the Air Force, so that NASA is in a sense moving into a completely new vehicle development program in this field. Is that not correct?

Dr. SILVERSTEIN. Yes, sir.

Mr. SISK. My only question would be, then: Do you feel very strongly that you can spend efficiently, in the next fiscal year, $41 million on this program?

Dr. SILVERSTEIN. Yes, sir. The development of this contractual relation is far enough along so that it is quite clear how the money can be spent—how it will be spent.

Mr. SISK. In other words, the point I am making is that, to be frank, do you feel, for example, if you had $30 million in 1960 and then pick up the other $10 million or $15 million or whatever you needed in 1961, do you think that would tend to hurt the——

Dr. SILVERSTEIN. It would definitely hurt the program in the sense that we are in a position now to move ahead quite rapidly. We ought to move at a rate which will move our capability ahead as fast as we can see in a reasonable way. We are not asking to move any faster than that, but that is the rate at which I think this country should move, at the rate at which we can see clearly how to move. This is what our program has in it.

Mr. SISK. Are there any further questions? Does consultant have any questions?

Mr. WILCOVE. No questions.

Mr. SISK. That completes the presentation, then, on our vehicle development. As I recall, this morning we approved, from the standpoint of our recommendations, the Scout program. Did we take action on the Delta program? I believe we did, did we not? Or did we pass that over? We passed over it, that is right.

So actually what we have now to consider is the Delta, Vega, and Centaur programs. The Chair would like to know the pleasure of the subcommittee with regard to our recommendation.

I might say before we proceed there that I talked at lunchtime to the chairman of the committee, Mr. Brooks. It is my understanding that all the other subcommittees have completed their work and are waiting to submit their recommendations. As I told him, maybe I am a little bit laggard. However, I feel that we have been meeting about as regularly as we could since we were given this task. I believe we met Thursday afternoon, and Friday morning, and this morning, and again this afternoon. Maybe we have dragged this thing out unduly, although I do not feel we have when we figure we are dealing with $170 million-odd of the taxpayers' money and, at the same time, a very important program.

Mr. McDONOUGH. On the Centaur program, you are asking for six vehicles, Doctor. Could you not obtain from half that number of vehicles the same knowledge? After all, the $41 million provides for six separate units, six separate firings. Centaur is entirely new. You have described the difficulty of handling liquid hydrogen in the upper stages. You are certainly going to learn that after you have found out how to design the equipment to transmit it in the first one or the second one, or the third one.

The question is whether we should provide for a total of six at this time or a total of three, and then ask you to come back for supplemental funds if you find it necessary to ask for them.

Dr. SILVERSTEIN. We have carefully evaluated this point. The reason we ask for six is this: That there are programs we expect to carry on that are to meet a military time schedule. * * *

Mr. McDONOUGH. Centaur is a military vehicle?

Dr. SILVERSTEIN. The first of the missions for it will probably be a military mission, after that it will be used jointly. If you recall, in mentioning this national program, I pointed out these vehicles will be used both in the military program and in our program.

Mr. SISK. If I can, let me clarify this. If I recall, this entire program was covered by an Air Force presentation which we had some time ago when we were meeting in the Veterans' Affairs Committee room, at which a rather highly classified presentation was made. Without going into the details of that, the Centaur vehicle was the vehicle that was to carry the payload; is that correct? * * * Is that still a part of this program, even though it is now under NASA?

Dr. SILVERSTEIN. * * * So our six vehicles give us approximately three vehicles to initiate the development and we feel it will take this many with this type of vehicle. * * *

There is another factor here, too. This is a development, and the expensive part of this program is not described particularly by the number of vehicles. Large parts of these costs are the development costs. If we get fewer than six vehicles we will find that we will not have enough, and more than that, the manufacturer will lose time in bringing the equipment back to the point where it would have been if we had provided enough to start with. On our evaluation of all these programs, we look at the lead times, try to anticipate the history which the vehicle will go through in its development and the launch problem, and then we pick out the number of vehicles which best describe the balance between the program development and the costs.

I feel sure that if we were to buy three vehicles initially and then go back for three more, the cost of the program would be higher than buying six initially.

Mr. SISK. I was going to ask you. You are asking here for $41 million, which involves six vehicles. If you went to three vehicles, what are you going to ask for? Let us assume that you had a mandate to operate at present on three vehicles. Based on the costs and other considerations by the contractor and so forth, what are you going to ask for? You would have to request in the neighborhood of $30 million or $28 million or $35 million?

The point I am trying to make here is, out of this $41 million, as I understand your statement, you are going to lose a substantial advantage that might be gained in your contracts and so forth by—it

certainly is not an assembly line production—but by increasing the number of units which they are going to build. There are certain basic costs involved here that it is going to cost you that figure whether you build 1 vehicle or 10 vehicles. Is that not right?

Dr. SILVERSTEIN. That is right. By the time you finish the three, if you tear down, as you must do in these plants, the setup by which you have created these three, before you have arrived at the number of vehicles to carry out the program, then you are in the position of having to set it up again and rebuilding is very expensive.

Mr. MCDONOUGH. In other words, you are not committing the $41 million for six vehicles all at one time?

Dr. SILVERSTEIN. No, they are stretched out. It is a continuous program and they will come off the line and be fired in series, and we do not want the vehicles to come along too far apart because when we do that, then we are in difficulty at our launch site. The launch groups here are very special. We have got a very special technique here. The people we put together to do this job are going to have to be specialists.

Mr. MCDONOUGH. Let us presume that you have a vehicle ready for firing today and you have five others on the line coming along. The one you fire, you find a defect in it that is in the other five coming along the line. What are you going to do? In other words, you cannot say that the design of the first one is going to be the same as the design of the last one.

Dr. SILVERSTEIN. I think we will find that outside of minor variations, that they will be quite alike. For example, we may find there is a valve in one of them that is not right or that the instrument we have for measuring the flow rate is incorrect. But these are modifications that we will put on as we go through the system.

Mr. MCDONOUGH. Another question in my mind is why do you need so much more power in the escape velocity in this vehicle * * *

Dr. SILVERSTEIN. * * *

Mr. MCDONOUGH. What distance from the earth would this 24-hour vehicle be?

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Mr. HALL. What would be the life of that vehicle?

Dr. SILVERSTEIN. The life will be almost indefinite. This is one of the reasons we need advanced technology in auxiliary power systems, so that we can provide power so it can keep on working as it stays up there forever.

Mr. SISK. Are there any further questions of our witnesses? If not, we are going to dismiss these gentlemen.

We deeply appreciate, Dr. Silverstein, the efforts of you and all your people in presenting this. I think you have done a very fine job and made your case very well. With that, we will say a job well done.

I might say to my colleagues, if you will remain here a few minutes, we will discuss a little procedure, in view of the fact that Mr. Riehlman of New York was—due to previous commitments—unable to be with us this afternoon. He is very much interested and very much concerned with this program.

(Whereupon, at 4:15 p.m., the subcommittee was adjourned.)

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